

Order

558
68657
1881

Division of Fishes,
U. S. National Museum

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

CONTRIBUTIONS
TO THE
NATURAL HISTORY OF THE FRESH WATER FISHES
OF
NORTH AMERICA.
BY
CHARLES GIRARD.

I.
A MONOGRAPH OF THE COTTOIDS.



BY THE SMITHSONIAN INSTITUTION,
DECEMBER, 1880.

COMMISSION
TO WHICH THIS PAPER HAS BEEN REFERRED.

DR. JARED P. KIRTLAND,
DR. J. E. HOLBROOK.

JOSEPH HENRY,
Secretary.

P R E F A C E.

I HAVE selected the Artedean genus *Cottus* as the subject of my first monograph, on account of the interest which attaches to the questions involved in its investigation. The first of these questions is to ascertain whether there really exists but one single species of the genus in Europe, and another in America. The second, whether indeed the same species is common to both countries, as was at one time supposed.

My investigations embrace, and, I hope, solve both of these questions. The materials made use of are numerous and of special value; some of them absolutely essential to the proper determination of the above-mentioned points.

As far as it has been in my power, I have consulted the original documents, and their authors themselves. Thus I owe to Professor S. S. Haldeman an authentic individual of his *C. viscosus*. Through the kindness of Professor James Hall, of Albany, I have studied the specimen drawn and described by Dr. De Kay under the name of *Uranidea quiescens*, which proved to be a true *Cottus*. Mr. W. O. Ayres has placed in my hands specimens of his *C. gobio* from the State of Connecticut. From information communicated by Dr. J. P. Kirtland, of Cleveland (Ohio), I have identified his *C. gobio*. Rev. Z. Thompson, of Burlington (Vt.), has sent me a species hitherto undescribed. Specimens caught near the White Mountains were communicated by Dr. D. Humphreys Storer. I have made a complete study of the species brought by Prof. Agassiz from Lake Superior.

In examining the collection of fishes in the Academy of Natural Sciences of Philadelphia, with the assistance of Dr. J. Leidy, I found one specimen by which I became fully satisfied of the existence of two species in the tributaries of the Ohio River. But the most important contributions have been from the collection of Professor S. F. Baird, now at the Smithsonian Institution. Numerous specimens of *C. viscosus* and others have enabled me to give the anatomical details contained in Chapter II.

I beg all these gentlemen to accept the assurance of my deepest gratitude, and to receive my labor with the same indulgence which they have shown towards me during its elaboration.

Most of my descriptions rest upon the examination of numerous specimens: a few of them are drawn from one individual, but the species will appear distinct enough to be justified.

Those ichthyologists who may deny the validity of all the species of the genus *Cottus* which I adopt, considering some of them as mere varieties, must still acknowledge that these varieties are worthy of being known.

There are two species of *Cottus* proper, the originals of which I have not seen, viz.: *C. cognatus*, Rich., and my *C. Fabricii* (*C. gobio*, Fabr.). No specimens of either of these species are preserved in any American collection.

An intimate knowledge of the Cottoids will enable us more readily to appreciate the specific characters of a great many other groups, whose geographical distribution is less extensive, but in which the species are altogether as numerous and as uniform. The species of a genus are generally uniform whenever they are numerous: this is a necessary consequence. When the type possesses but a few characters, it is not liable to so many diversities amongst the species, and these characters, in being shared, appear as if exhausted, leading superficial observers to the belief that species pass into each other by gradual steps.

Not only among fishes, but in other classes also we meet with natural groups composed of numerous species, which are allowed to vary beyond the limits of their circle of activity, and for the study of which great skill must be displayed in order to recognize the species in the midst of these variations.

CHAPTER I.

ON THE FRESH WATER COTTOIDS IN GENERAL.

§ 1. ZOOLOGICAL CONSIDERATIONS.

FOR nearly a century a single species of fresh water Cottoid was known in Europe, a small fish very common there in rivers and lakes, and whose obtuse form and flattened head (which is broader than the body) brought it to the notice of every one. A long time before ichthyologists gave it a systematic name, many nations, including the French, English, Danes, Swedes, Germans, Italians, Hungarians, and Russians, had assigned to it a vulgar one in allusion to the breadth of the head, which in fact is the chief character of the genus; and this generic character, so clear and so precise, involved the apparent uniformity among the species. For this reason the species were not at first distinguished, being referred from vague recollection, and from the opinion of the people, to the *C. gobio* of Artedi and Linnæus. Thus the same species was believed to inhabit the fresh waters of nearly the whole ancient hemisphere, in Europe from Sweden to Italy, and from France to Siberia. Cuvier, however, after having enumerated the localities which the *C. gobio* inhabits, adds: "But perhaps it would be necessary to see together and to compare individuals from countries so remote from each other, in order to ascertain that they do not present some differences which have escaped isolated observers."¹ From this moment suspicion began to be entertained: this was to be the prelude to new researches.

Thus eight years after these lines were written, Mr. Heckel,² taking up the study of the Cottoids, distinguished three new European species; namely, his *Cottus affinis*, *microstomus*, and *pæcilopus*. The first inhabits Scandinavia, and had been referred by Eckström³ to *Cottus gobio*, and in fact it is the fish that Artedi and Linnæus had in view, though not specially, since they gave to their species, as geographical range, the whole continent of Europe. *Cottus microstomus* is from the vicinity of Cracow, and *C. pæcilopus* from the Carpathians in Upper Hungary.

Some time afterwards the same naturalist wrote to Ch. L. Bonaparte that *C. gobio* from Italy was a distinct species, and gives to it the name of *C. ferrugineus*.⁴

¹ Histoire Naturelle des Poissons, iv., 1829, 8vo., p. 150; 4to. ed., p. 110.

² Ichthyologische Beiträge, in Ann. des Wien. Mus., vol. ii., 1837, p. 150.

³ Fiskarne i Mörkö Skärgård, p. 139.

⁴ Catalogo Metodico dei Pesci Europei di Carlo L. Principe Bonaparte, Napoli, 1846.

In our *Revision of the genus Cottus*,¹ we advanced the opinion that this species would be found distinct, not knowing at that time that it had been already named.

These were progressive steps in European ichthyology, but there still remains carefully to compare with the above species, the *C. gobio* of England, France, Denmark, Germany, and Russia, in order to ascertain whether several species are not still confounded. We have already remarked a certain disagreement on this subject among authors. Cuvier makes the positive remark that the *C. gobio* has only three soft rays to the ventral fins, whilst Dr. Richardson mentions four as belonging to the English species examined by him, and which is the same as the one described by Mr. Yarrell. This also has but six spinous rays to the first dorsal, and sixteen soft and articulated, but unbranched rays, to the second dorsal. The assertion of Cuvier, that the first dorsal of *C. gobio* counts from six to nine spinous rays, is a fact to be verified anew: perhaps the above English species is taken into account in the formula. Moreover, Cuvier says, positively, that the rays of the centre of the second dorsal dichotomize at their extremity. Finally, in the *C. gobio* of the Seine the upper rays of the pectorals are branched, whilst they are all simple in the English species spoken of by Dr. Richardson.

Should these differences prove constant, and we have no doubt they will, they are more than sufficient for specific distinction, and we are satisfied of the existence of two species of *Cottus* in the British Islands, for we find mentioned sometimes three and sometimes four rays to the ventrals of the so-called *C. gobio*. This character, which proves safe among American species, will no doubt be a sure guide in a critical review of the European ones. We have seen a mutilated specimen of an English Miller's Thumb with evidently branched pectoral rays, therefore differing from the one alluded to by Sir John Richardson. The Miller's Thumb from the Seine again differs from that of the Danube. Those of the Rhine, of the Rhone, and the south of France generally, deserve a special attention, as well as the one mentioned by Reisinger in his *Ichthyologiæ Hungariæ*, which seems to attain a very large size. In fact, the Cottoids of all the European and Asiatic rivers and lakes should be compared directly. It is only after this is done that we shall be prepared to establish safe comparisons between the species of one continent and another.

Now, if we recapitulate the European species, we find five of them to be well determined and named. In addition, we have two species in England as alluded to above, which are distinct from *C. gobio* of the Seine; thus giving seven species. Then, in central Europe several other species will probably be found distinct. *C. pæcilopus* must be compared with the *gobio* of Reisinger, of the Danube. Be it remembered that the latter spawns in March and April. A comparison of the *C. gobio* from the Seine (spawning in May, June, and July) with that of the south of France, and then again with that of the Swiss lakes and the rivers of continental Europe, would no doubt add to the number of species. It would be interesting to know whether the Miller's Thumbs exist southwards of the Pyrenees, in Spain and Portugal, as well as in Greece and Asia Minor.

¹ Nouveaux Mémoires de la Société Helvétique des Sciences Naturelles, vol. xii., 1851.

We may thus expect in Europe a number of species nearly equivalent to that of America, and we shall find among them species with four soft rays to the ventrals, and others with only three. Whether the lateral line will be found extending to the tail in all of them, is a point worthy of attention.

Let us return for a moment to Mr. Heckel's paper. Six species are found mentioned there, of which four belong to Europe, *C. gobio*, *microstomus*, *pæcilopus*, and *affinis*, and two to America, *C. cognatus* and a new species which the author calls *C. gracilis*. Now, in his synoptic list, this latter is the only one which has but three soft rays to the ventrals, whilst the other five have four. Mr. Heckel does not tell us whence he obtained the *C. gobio* which he had before him, which would be of great importance to us, for we have seen that it is not perfectly identical with that of the Seine, since Cuvier allows to this latter only three soft rays in the ventrals, and Mr. Heckel cites four of them. In the *C. affinis* the rays of the ventrals are divided; in *C. gobio*, *microstomus*, *pæcilopus*, and *cognatus*, they are simple. The upper rays of the pectorals are branched in *C. gobio* and *microstomus*; they are all undivided in the *C. pæcilopus* and *cognatus*.

Thus we see Mr. Heckel borrowing the specific characters from the structure of the fin rays. He says he has examined a large number of fishes in order to ascertain the variations which the rays undergo during their growth. He has observed that in his *C. gobio*, for instance, the bifurcation of the rays commenced only when the fish had acquired half its size, whilst he has never seen the least trace of division in the *C. pæcilopus* even at a size much beyond that at which the phenomenon takes place in the *C. gobio*. From this fact he concludes that there are constant characters of which we may avail ourselves for the distinction of species. He denies the influence of climate on the division of the rays, as for instance, that this division would take place under warmer climates, and he cites as a proof of the contrary the *C. pæcilopus*, the most southern of his species, whose rays are undivided, whilst they are branched in the more northern *C. microstomus*.

When a genus happens to be as uniform as that of Cottus, it is a natural and necessary consequence that we should take into consideration the minutest details in discriminating the species. Did the Cotti present themselves uniform from one extremity to the other of Europe, and were the species of America or of Asia more diversified in their forms, there would be less reason for our undertaking so minute a study of them. But their uniformity in all parts of the globe where they have been observed is such as to lead us to researches of details; for, howsoever a question of that nature be definitively solved, be it in favor of a single species or of a multitude, these researches will lead us to the understanding of the ichthyic signification of the genus to which they have reference, and to its distribution over the surface of our globe.

C. gobio, L. has been cited by Oth. Fabricius as an inhabitant of Greenland. This is undoubtedly a particular species, which we shall mention hereafter.

Again, *C. gobio* was thought to inhabit the United States, and as the present labor was undertaken with a view to verify the assertion, we have no remarks on this subject to make in this paragraph.

The Cotti of Asia are little known, the centre of this great continent not having

yet been sufficiently explored. We may expect many species from the rivulets of the highlands and slopes of mountains, as well as in the valleys; for Pallas cites a *C. gobio*, L. in the lake Baikal and the fresh waters of Siberia; but it is more than probable that this is a distinct species. He describes another under the name of *C. minutus*, which was sent to him by Merk as coming from the fresh waters which empty into the Ochotsk sea. It resembles so closely *C. gobio*, described in the *Histoire Naturelle des Poissons*, that Cuvier himself says that he dares not separate it. And yet he does not identify it absolutely with the *C. gobio*, leaving for it a place apart in making the observation that "its snout is perhaps a little less pointed, and the spines above its nostrils a little larger," without giving his opinion on the value of these differences. The size of the specimens which he has examined measured three inches, and if this be the common size, the species is smaller than the *C. gobio* of the Seine, and many others.

There is, in this reserve of Cuvier, not to identify definitively two fishes of such distant countries, and nevertheless so similar to each other; there is, I say, included in this reserve, the whole spirit of modern science, a spirit profoundly philosophical, the spirit of future progress.

We have deemed it necessary to make several generic divisions of the species hitherto comprised in the genus *Cottus*. This part of our labor was published in the *Proceedings of the Boston Society of Natural History*,¹ and we think it in place to transcribe here the historical paragraph which relates to that question, since it might be controverted by some one.

Artedi established the genus *Cottus* in 1738 with the following characters: gill membrane containing six distinct bony rays; head larger than the body, depressed and acute. Two dorsal fins; the anterior composed of flexible spines. Ventral fins small, having only four soft rays. Skin scaleless.²

He places in the first rank the fresh water species having *two spines* on the head, of which *C. gobio* is the type, being the only one known at that time. Next to this, the species with more spines on the head, including not only the salt water species having a smooth skin, but two others, which have since become, one the type of the genus *Aspidophorus*, the other the type of the genus *Callionymus*. Artedi himself went thus beyond the limits of his genus by placing in it the two last species, as their body is covered with scales.

Linnaeus³ alters Artedi's genus by giving as the only character for it, "a spiny head broader than the body." Linnaeus went farther; he transposes the species and places at the head *C. cataphractus*, the type of the genus *Aspidophorus*, of later date, and which Artedi placed at the end of the genus *Cottus*. His third species belongs now to the genus *Batrachus*, and the fourth to the genus *Platycephalus*: the *C. gobio* is the last.

Oth. Fabricius⁴ followed the example of Linnaeus.

But Cuvier⁵ recalls that the primitive type of the genus *Cottus* was *C. gobio*

¹ Vol. iii., 1850, pp. 183, 303, and vol. iv., 1851, p. 18.

² Genera Piscium.

³ Systema Naturæ, ed. xii.

⁴ Fauna Groenlandica, 1780, p. 159.

⁵ Histoire Naturelle des Poissons, iv., 1829, pp. 142, 150.

from the fresh waters of Europe. Following Artedi's method, he describes first the fresh water and next the salt water species. Nevertheless, when writing the history of this genus, he did not find it necessary to separate generically these two groups, although he had already pointed out their principal difference. Two species only were known to him, one of them (*C. minutus*, Pall.), very imperfectly.

On ascertaining the actual number of species to be so large, and each group still maintaining constant generic differences, we concluded to give the name of ACANTHOCOTTUS to the marine species, which, generally speaking, are of a larger size than those living in fresh water. They are characterized by having many spines to the opercular apparatus; the preopercular itself having several of them always strongly developed. The surface of the head, and often the circumference of the orbits also, are either armed with spines, or else serrated or notched in different ways. The nasal and turbinal bones are in most of the species surmounted by a spine or ridge. The head itself is rather higher than broad; sometimes much deformed, with proportionally large eyes, and a deep occipital depression, as for instance, in *A. ventralis* and *claviger*. The mouth is always more deeply cleft than in the fresh water species (*Cottus* proper), but the dentition, as a whole, is nearly the same. The nostrils open exteriorly by two apertures quite distant from each other, the anterior tubular, and much larger than the posterior, which is even with the surface of the head, and situated close to the orbits. The body is scaleless; the back is often arched, and the first dorsal fin almost as high as the second. Some species have three, others four, soft rays to the ventral fins. The lateral line runs uninterrupted and distinct from the head to the base of the caudal fin.

The name of *Cottus* is retained for the fresh water species, the subject of the present monograph, and as the generic characters will be given hereafter, it is unnecessary to present them in this place.

Not long since, the generic name of *Uranidea* was given to a species of our genus *Cottus*, and had the name of *Cottus* belonged to the marine species of the group, instead of being founded on the fresh water *C. gobio*, the new name *Acanthocottus* would have been unnecessary. In that case we might have called the fresh water species *Uranidea*, and the marine ones, *Cottus*, with equal propriety, although the original idea of the genus *Uranidea* was a mistake of its author.

We have formed another genus under the name of COTTOPSIS, to include one single species, the *Cottus asper*, originally placed in the genus *Cottus* by Sir John Richardson, afterwards in the genus *Trachidermis*, by Mr. Heckel, and again by Sir John Richardson, in that of *Centridermichthys*. The genera *Trachidermis* and *Centridermichthys* have proved to be identical,¹ and in addition, to have no immediate affinities with *C. asper*. The history of the genus *Cottopsis* will be found in Chapter IV. Finally, we have established the genus TRIGLOPSIS² for an entirely new fish discovered by Prof. Baird in Lake Ontario. It comprehends as yet, only one species, the description of which will be found in Chapter V.

The manner in which the characters are shared by the genera of Cottoids, either

¹ Proc. Bost. Soc. Nat. Hist., iii., 1850, p. 302.

² Proc. Bost. Soc. Nat. Hist., iv., 1851, p. 19.

marine or fluviatile, shows a very intimate relationship, both amongst themselves and the neighboring groups of Scorpænoids and Sciaenoids.

The typical genus of the marine division is that of *Acanthocottus*, numerous in species, and distributed over the arctic and temperate regions of both hemispheres. In the Pacific Ocean we have the genera *Trachidermis* and *Podabrus*, composed each of but a few species confined to the seas of China and Japan. The first is a diminutive of *Acanthocottus*, from which it differs in having a prickly skin and teeth on the palatine bones. The second is intermediate between *Trachidermis* and *Acanthocottus*, without forming, however, any direct passage from one to the other; it has the smooth skin of *Acanthocottus* and the palatine teeth of *Trachidermis*. As to the general form and physiognomy, one would consider *Podabrus* as the eccentric type of *Acanthocottus*: the two species which it embraces, differing greatly from each other in that respect.

The genera *Hemitripterus* and *Hemilepidotus* exhibit a tendency towards Scorpænoids; both are provided with teeth on the palatine bones, the skin of the former being somewhat prickly, and that of the second, partly covered with scales.

The typical genus of the fresh water division is that of *Cottus*, numerous in species, distributed over the whole range of the temperate region of both hemispheres. On the north-western shores of America there is the genus *Cottopsis*, the amplification of *Cottus*, provided with a prickly skin and teeth on the palatines, like *Trachidermis*.

Finally, the genus *Trigloporus* seems to recapitulate both *Acanthocottus* and *Cottus*, and to foreshadow the group of Sciaenoids.

Thus eight genera, five marine, and three from the fresh water, constitute actually a natural group to which the name of COTTOIDS is well appropriated.

§ 2. GENEALOGY OF THE COTTOIDS.

The history of the Cottoids prior to our epoch rests, as yet, only upon the discovery of a few fossils in Europe. The family appeared for the first time on the surface of the globe, sometime during the last period of the cretaceous epoch, where it was represented by two genera, *Pterygocephalus* and *Callipteryx*, precursors of the group of *Triglidae*; their affinities leave no doubts on this point. But these two genera die out with the end of their epoch.

To them succeeds the genus *Cottus* in the tertiary epoch, where it was the only one of the family, and, indeed, had but few known species. Two of these, *Cottus brevis* and *C. papyraceus*, Agass., come nearest to *C. gobio* and other fresh water species of the genus now living, and a third species, *Cottus aries*, Agass., is more intimately related to *Cottus scorpioides* and *bubalis*, precursor of the marine type of the genus, which we now call *Acanthocottus*.

It is not improbable that Cottoids may have existed in North America before the present epoch. The study of the cretaceous and tertiary deposits situated within the limits of the zone inhabited by living species will furnish us information on this point.

The geological researches on the Asiatic Continent, have not yet furnished us

with a single palæontological fact which could lead us to suppose that Cottoids have existed there at an epoch prior to the present. On the other hand, we have no reasons to pronounce their total absence in the strata of that continent, since living species are found in its rivers and lakes.

§ 3. GEOGRAPHICAL DISTRIBUTION.

The fresh water Cottoids are distributed all over the cold regions of the Temperate Zone of the northern hemisphere, in Asia, in Europe, and in America. They do not generally associate with the Acanthocotti and other allied genera, beyond the arctic circle, around the polar seas, nor do they follow the other representatives of the family in the warm region of their geographical range.

In Asia, entirely towards the east, in the neighborhood of the Ochotsk Sea, between the 50th and 60th degrees of latitude we find the *C. minutus* of Pallas. That illustrious traveler cites the *C. gobio* in the Lake Baikal, and in the fresh waters of Siberia, which will probably prove to be a new species, if not identical with his *C. minutus*.

To the north of Europe, in Scandinavia, we have the *C. affinis*, Heck. More to the centre and to the east of that continent, in Poland, the *C. microstomus*, Heck., and still more in a southerly direction, in Hungary, the *C. pæcilopus*, Heck., but confined to the chain of Carpathian Mountains.

In the central and western part of Europe, from and including the British Isles, to the chains of the Alps and Pyrenees, a single species is cited, the *C. gobio*, L. But we know already that Great Britain has peculiar species even if the *C. gobio* should prove to be ~~an~~ inhabitant.

/several
/one of its

Finally, we find on the southern slope of the Alps, in *Laggo Maggiore*, and in the north of Italy, another species, the *C. ferrugineus* of Heckel.

The Cotti of America are almost parallel with those of Europe. In the north of the continent, and near the arctic circle, is found the *C. cognatus*, Richards. In Greenland, and detached from the continent, but nearly in opposition to *C. affinis* of northern Europe, we have *C. Fabricii*. Southwards, but still in a comparatively eastern range, in the basin of Lake Superior, we meet with two species, the *C. Richardsonii*, confined to the northern shore and the *C. Franklinii* inhabiting the southern and eastern shores. Again, in the water emptying into Lake Huron the *C. Alvordii*, and in the depths of Lake Ontario, *C. formosus*. Along the western slope of the Green Mountains, occurs the *C. gobioides* and on the eastern slope of the same range, *C. boleoides*. In Massachusetts, New York and Connecticut we have the *C. gracilis*, Heck. East of the Alleghany range, are found in Pennsylvania the *C. viscosus*, and in James River (Virginia), the *C. meridionalis*. West of the Alleghanies we know of the existence of two species, one, *C. Bairdii*, in the northern, the other, *C. Wilsonii*, in the eastern tributaries of the Ohio.

The southern limit where Cotti have been observed, is the State of North Carolina; but we do not know yet to which species they belong.

Again, in Lake Ontario we find a species combining such characters as to consti-

tute a genus by itself, the genus *Triglopsis* associated there with a species of *Cottus* proper.

Passing to the western coast of the American Continent, beyond the Rocky Mountains, between the latter and the shores of the Pacific, we shall find in the Columbia River another species with a special combination of generic characters, the *Cottopsis asper*, associated with a yet undescribed species of *Cottus* proper, collected by the naturalists of the United States Exploring Expedition. The published ichthyology of that exploration will soon make us acquainted with other members of the Cottoid group.

If we take a glance on a chart at the localities of the North American Continent where Cottoids have been observed, we shall find extensive tracts which still remain unexplored; all the country west of the Mississippi and Ohio, and in a northerly direction to Lake Superior. Then, again, the British Possessions, that region of numberless lakes, must contain some of these fishes, since we see that one species extends as far north-west as Great Bear Lake, the northernmost of all. Between Lake Superior, the mouth of the Columbia River, Great Bear Lake, and Labrador is included a vast area where Cottoids will undoubtedly be found hereafter, as well as within the limits of the western part of the United States, between the Mississippi and Ohio, to the shores of the Pacific. But how far south they occur we cannot yet tell with certainty. We know that fresh water Cottoids belong chiefly to the temperate zone, having been observed from the arctic circle to the 45° of latitude in the eastern hemisphere, and to the 35° in the western hemisphere.

§ 4. HABITS, FOOD, AND USE.

We have not had the satisfaction of observing ourselves the Miller's Thumbs of this continent in their natural medium. All authors agree in saying that clear and limpid waters with stony or sandy bottoms, are the places most preferred by these fishes. The small rivulets of cold water descending along the slopes of mountains are often their favorite residence, although likewise frequently inhabitants of large lakes. They keep sheltered under stones, which must be removed when in search of them. When uncovered, they sometimes dart away with great rapidity, in search of another hiding place; and sometimes they wait motionless until started. In Europe, there is scarcely a boy living in their vicinity who does not hunt them by uplifting carefully and slowly the stones of the shores of lakes, or at the bottom of rivulets, and transfixing the fish when motionless, by means of a fork attached to a stick.

They are of little use to man, not to say in the economy of nature. The marine species are dreaded, being exterminated by fishermen, and generally thrown away when sufficiently mutilated. Sometimes, however, we see the head only cut off, and the body brought home for the table. The flesh of the fresh water species is delicate and much esteemed in some countries of Europe, where they occur in large numbers. Undoubtedly they would be much more sought for, if not generally so scarce and of a size too small to repay the trouble of hunting them. In fact,

they are only accidentally taken either with the hook or the net, and must be, as already remarked, sought for under stones. In the United States where the markets are abundantly supplied with larger fishes, the Miller's Thumbs pass entirely unnoticed.

Some species spawn in the spring, others in summer, from the month of March to July. When only one species was admitted in both continents, the difference of latitude in America was called on to explain the difference in spawning. Thus, to see the Cottus of the State of Connecticut spawn in March and April, and those in the Great Bear Lake only in May, appeared quite natural. But how explain the fact, that in the Seine, at Paris, the *C. gobio* spawns in May, June, and July, whilst in the State of Connecticut it spawns in March and April? The isothermal of Paris, it is well known, passes below that of any part of Connecticut. The Cotti of the Danube again, spawn in March and April.

It has for a long time been known that certain fishes construct nests, such as Sticklebacks. Others take care of their spawn and young; so do the lump-fish, the cat-fishes, and, according to Fabricius, the male of his *C. gobio* does the same. We know nothing of the behaving of other Cottoids in this respect.

The food of Cottoids consists generally of crustaceans, insects and of their larvæ. Fabricius says that his *C. gobio* feeds on ammodytes (Sand eel) *Holothuria priapus* (Sea cucumber), worms and small fishes. Sir John Richardson tells us that fragments of small fish were found in the stomachs of *C. cognatus*. We have examined the contents of the stomach of many marine and fresh water Cottoids, and in the Acanthocotti of the Boston Bay found them to consist of crabs (*Pilumnus Harrisii*); in *Cottus viscosus* and *gracilis*, of insects and larvæ, and in *Trigloopsis Thompsonii* of shrimps. We have never found any indications of fishes.

CHAPTER II.

ANATOMICAL OBSERVATIONS.

§ 1. GENERAL REMARKS.

It is not our intention in this place, to present the Anatomy of the Cottoids further than what may be necessary to the complete Zoological discrimination of the genera and species. Nevertheless, if we have given more anatomical detail than may be necessary for the above object, we would have this considered as so much towards a complete anatomy, which we trust may some day be furnished.

§ 2. THE BONY FRAME OF *COTTUS VISCOSUS*.

PLATE III. Fig. 1—9.

The skeleton (Fig. 1), is intended to give a general idea of the internal frame. The first vertebra is concealed by the scapular; the first and eighth ray of the first dorsal fin are omitted by accident.

The skull (Fig. 6—9), or that part of the head composed of the occipitals, parietals, frontals, mastoids, vomer, nasal, ethmoid, petrosals, and sphenoid, may be subdivided into two regions. An anterior region composed of the vomer, nasal, ethmoid, prefrontals and part of the sphenoid constituting an arcade over the eyes, on both sides of which are the orbits. The posterior region is more bulky; it is the solid box which contains and protects the brain.

Seen from above (Fig. 6), and below (Fig. 7), the general form of the cranial box is a little longer than wide, and the width behind, on the occipital region, is considerably greater than in front, near the orbits. The upper surface is smooth, a little depressed in the middle, whilst the occipital region is rather convex, (Fig. 9.) The profile (Fig. 8) shows more accurately the extent of the two regions; the orbito-frontal arcade having exactly the same length as the cranial box; besides, we observe a character which is peculiar to *C. viscosus*, at least amongst the species figured on Plate III, that is the great convexity of that arcade. The same character is very likely to be found in all the species whose external features exhibit a very truncated snout, such as *C. Alvordii*, *C. meridionalis*, &c.

The movable bones of the left side of the face and head in general are represented isolated in Fig. 5^a. The *premaxillary* (22) has the form of a right angle; both of its branches being of equal length. The horizontal one is a flat ellipsoidal piece pro-

vided with card-like teeth. The vertical portion is composed of a spine and a flattened process situated behind the spine, but in close contiguity with it, and reaching only to half the height of the latter. The *maxillary* (21) which constitutes with the premaxillary the upper jaw, is articulated anteriorly with the vertical branch of the premaxillary, and a little covered by the suborbitals. Its posterior extremity is kept movable on the membrane, which forms the angle of the mouth. Its form is elongated, slender, a little curved, subcylindrical, flattened behind, and provided in front with an articulating trifold head.

The vault of the palate is formed by three bones, closely soldered together, constituting an arcade, which rests behind on the hypotympanic and pretympanic, abutting in front against the vomer and premaxillary. The first of these bones is the *palatine* (20), irregular in shape, and provided with several flat, wing-like expansions, on which no teeth can be seen. The *entopterygoid* (23), and *pterygoid* (24), come next to the palatine; they are both of nearly the same length, and so intimately connected that we did not venture to separate them for fear that we should break the only specimen which was at our disposal. The pterygoid is uniformly elongated and flattened; the entopterygoid is flattened and elongated also, but terminated posteriorly in an expansion, crescent shaped behind, resembling somewhat a forked caudal fin.

The *dentary* (32), is not quite as much curved as exhibited in the figure. Teeth exist on the whole width and length of the upper branch, which extends a little more backwards than the lower one.

The *articular* (29), has still adherent to it the *angular* (30), at its lower and inferior corner, and the *splénial* (31) inwardly and above, which for the same reason as mentioned in the case of the pterygoid and entopterygoid, we did not attempt to separate. The angular and splénial are very small bones, insignificant in their shape, which could only have been drawn of natural size with great difficulty. Our object is to signalize their presence and their homology. The articular itself is a stout and well developed bone, and so characteristic in all osseous fishes that it could hardly be mistaken. The *hypotympanic* (28), irregularly triangular in shape, is provided at its summit with a rounded head which articulates on the articular and splénial. The body of that bone is a flat disk protected on each side by a spine which extends a little beyond the central disk. Above the hypotympanic, and encroaching into the forked extremity of the entopterygoid, is the *pretympanic* (27), a very thin leafy bone, so delicate that in detaching it from its neighbors it is constantly torn along the edges. As represented in the figure, the outline above has lost its actual shape. The *mesotympanic* (26), is likewise almost a mere membrane, or a thin cartilage, in the middle of which two points of ossification are distinctly seen. The mesotympanic forms the continuation of the lower extremity of the epitympanic. The *epitympanic* (25), itself, articulates above with the mastoid. It is somewhat covered by the upper part of the preopercular. The epi-, meso-, pre-, and hypotympanics are all intimately connected, and form the back roof of the mouth, limited behind by the concavity of the preopercular. The palatine arcade extends from its anterior edge to the vomer and premaxillary, thus continuing the roof to the anterior part of the mouth. The upper angle of the

preopercular is attached to the medial crest of the epitympanic, whilst the lower angle articulates on the body of the articular.

The *preopercular* (34), is an exact crescent, on the convexity of which is situated the conical spine, directed obliquely upwards. The insertion of the spine is above the middle of the crescent. The concavity of the latter is occupied by a thin expansion of that bone, making the direct continuation of the tympanic wall.

The *opercular* (35), is articulated to the posterior articulating process of the epitympanic. It is irregularly triangular like the hypotympanic and formed likewise of an articulating head at its summit, and of two branches, between which is a thinner expansion of that bone.

The *subopercular* (36), is provided at its lower edge with a spine whose point is directed downwards and forwards, a little more conspicuous than in the figure. That bone sends off two branches, a spiny one directed upwards which unites with the inner edge of the opercular, and another thin and membranous, running all along the posterior and free edge of the same bone, and in fact, constituting the actual edge of the opercular.

The *interopercular* (37), is an elongated and narrow piece, very uniform in shape, pointed forwards, truncated behind, extending from the subopercular behind, to the hypotympanic and articular, in front. In a fleshy specimen it is not apparent, being covered by the lower branch of the preopercular. When the skin is removed its edge may then be seen.

Amongst the bones of the head and face there still remain to be mentioned those which have been classified under the special denomination of dermo-skeleton.

To the dermo-skeleton belongs the lateral line which is described below in § 9, and figured on Plate II, Fig. 11. When the lateral line enters the head, it passes under the suprascapular into the mastoid groove, the posterior portion of which is covered by two thin and small bones, our *supramastoids* (8' 8'). From the mastoid groove a cartilaginous or bony tube composed of two pieces, runs downwards into the preopercular. These two tubular pieces we call the *supratympanics* (72, 72'), being the supra temporals of Prof. Owen.

In advance of the mastoid groove, and above the epitympanic, there are two other small tubular and horizontal pieces, our *supralachrymals* (73^a 73^b), of which the *lachrymal* (73), is the direct continuation downwards. The latter forms the posterior edge of the orbit.

The *suborbitals* (73'), are two in number; the posterior one is placed obliquely across the cheek, from the preopercular spine to the orbit, where it meets the lachrymal tube, which passes directly into the anterior suborbital, forming the inferior edge of the orbit. In advance of the latter, and near the centre of the snout, the *turbinal* (19) may be seen, small, irregular, with acute angles. Between the latter and the prefrontal there exists a very small, insignificant *supraorbital* (71).

The *hyoidean arch* is represented in Fig. 5^b. The *stylohyal* (38) is only half ossified; it is slender and elongated, resting upon the epihyal. The *epihyal* (39), is broad, short, and subtriangular, giving points of attachment to two of the branchiostegals. The *ceratohyal* (40), is the largest bone of the hyoidean arch, elongated,

narrower at the middle, and broad on both extremities. Four branchiostegals are attached to its lower edge.

The *basihyal* (41) is situated immediately above and in advance of the ceratohyal; its upper surface is flattened, subtriangular, and even with that of the ceratohyal. In advance of both the ceratohyal and basihyal, a small subconical *glossohyal* (42) may be seen. It does not extend into the tongue, which is not prominent in these fishes, but remains at the base of that organ, rather to indicate a plan of structure than to perform any active function. The thin and flattened *urohyal* (43) is situated between, and extends below, the glossohyal.

The *branchiostegals* (44) are six in number, slender, cylindrical, and curved.

The *branchial arches* (Fig. 5^c) are situated inwardly and behind the hyoidean arch, with which they are closely connected: their constituent bones we have now to enumerate.

The *basibranchials* (45) are not completely ossified; between the hypobranchials all along the medial line there exists a narrow band of cartilaginous substance, in which we observe small points of ossification, which represent these bones. The *hypobranchials* (46) are entirely ossified; the anterior one is the longest, the fourth, or last, is rudimentary, the second and third are soldered together, forming a flat expansion with two articulating surfaces, for two ceratobranchials. The anterior hypobranchial is flattened in the same manner as the following ones. The *ceratobranchials* (47) are simple, arched, provided on their concavity with small tubercles, on which minute needles may be seen. The respiratory fringes occupy their convexity, which is grooved for the passage of the blood-vessel carrying that fluid into the fringes. The *epibranchials* (48) differ very much in shape; the two anterior ones are elongated, almost straight, whilst the two others assume an irregular trifold appearance. The *pharyngobranchial* (49), irregularly quadrangular, is placed above the epibranchials, giving to the latter their upper point of attachment. The surface of that bone is beset with card-like teeth, though much smaller than those which exist on the jaws. The pharyngobranchial in *C. viscosus* is symmetrical, that of the left side is perfectly separated from that of the right. Besides, we observe here, two others, ovoid, symmetrical pieces (49') called by some *inferior pharyngeals*, and considered by others as a branchial arch, a ceratobranchial, beset with teeth. We leave to further investigation the decision of this question.

For the *scapular arch* we must return to our Fig. 5^a. We have already alluded to the peculiar situation of the *suprascapular* (50) which covers the paroccipito-mastoid groove articulating with both the paroccipital and the mastoid above, whilst to its external edge it holds the scapular. The suprascapular is irregularly quadrangular, provided above with a slender process curved upwards and inwards. The *scapular* (51) is elongated, subtriangular, and thin. The *coracoid* (52) is crescent-shaped, flattened vertically on the middle, and horizontally on both extremities. The upper extremity is considerably overlapped by the scapular, and provided on the inner edge with a slender and acute spine, on which the latter rests. The *epicoracoid* (53) is attached to the edge behind the union of the scapular and the coracoid. It is a cylindrical, needle-like appendage, which is kept within the thickness of the

skin of the thoracic region. It has nearly twice the size represented on the figure. There is no bone in the scapular arch which we can homologize with the humerus unless the so-called epicoracoid should answer for it. Indeed, we cannot help thinking that this styliform, rib-like bone (the epicoracoid) is the humerus itself, which having no part to perform in the plan of structure of Cottoids and others, has lost its primitive shape to assume that of the lowest production of the bony frame, a pleurapophysis, or a dermal spine. The *ulna* (54) above, and *radius* (55) below, having between them the *carpals* (56), three in number, build up a thin osseous band fixed by one edge to the convexity of the coracoid, whilst to the other edge the rays of the pectoral fin, the *metacarpophalangeals* (57), articulate.

The *ventral fins* (Fig. 5^d), are attached to the scapular arch itself, immediately under the head. The *pubic bones* (63) are elongated, subtriangular, in close contact with each other, and penetrating forwards between the coracoids, above the junction of these latter bones. Their central portion is very thin, whilst the edges are stout, the outer one sharply carinated. The rays or *metatarsophalangeals* (70) articulate immediately on the posterior extremity of the pubic bones. The outer one is a hard and unjointed spine, the head of which is lodged in a notch of the pubic bone. The other rays, the true metatarsophalanges, three in number, are soft and jointed.

The vertebral column is composed of thirty-one vertebræ, eleven of which are abdominal, (eight thoracic, three pelvic,) and twenty caudal. There are eleven pairs of ribs attached to the abdominal vertebræ; the pelvic vertebræ, in addition to the ribs, have suspended underneath, a pair of slender rib-shaped bones, very much inclined backwards. The *centra* of the thoracic vertebræ are subcircular, possessing only neurapophyses, which constitute a semi-lunar neural arch, of considerable development (Fig. 5^e β). Some of them may occasionally exhibit minute knobs on the sides, indicating the situation of the parapophyses. The seventh and eighth vertebræ show the first rudiment of hæmapophyses; their neural arch has become narrower and higher. The neural spines (*n s*) are intimately soldered with the neural arches throughout the whole length of the vertebral column.

The anterior pair of ribs is inserted at the basis of the neural arch itself, above the body of the vertebra, with its extremity fixed to the scapular arch by means of ligaments; the following pairs are merely kept within the fleshy walls of the abdomen, whilst their point of attachment to the vertebræ is gradually lower and lower till it takes place on the hæmal process of the pelvic vertebræ, after having passed through all the intermediate steps from the neural arch above. Figs. 30 and 31 exhibit the insertion of the first and last ribs of *Acanthocottus virginianus*; their larger size permits the illustration of this fact better than in the case of *C. viscosus*. The three pelvic vertebræ of *C. viscosus* are represented in Fig. 5^e (δ) in connection with two caudal ones. Under the middle one, and detached from it, is a pelvic appendage, the insertion of which is shown in the case of the tenth vertebra (α) having immediately above it the pair of ribs, the last but one of the series. The neural canal is growing narrow and high, diminishing gradually towards the tail (ε). The neural arch and neural spine (*n s*) become more erect and more slender (compare β with ε). The caudal vertebræ, when seen in profile, appear

more compressed than the abdominal ones; this is owing principally to the more erect position of the neural arch, and to the presence of hæmapophyses, building up a hæmal arch terminated by hæmal spines (*h s*), also intimately soldered together. The anterior hæmal arches are very much bent backwards, in the same manner as the anterior neural arches, but they soon become less so. The hæmal canal itself, likewise diminishes backwards. The neural and hæmal spines of the last vertebra but one (*γ*) are flattened and expanded. The terminal caudal vertebra is reduced to a very small centrum, which seems to be absorbed by caudal plates (*n' h'*), on the edge of which the rays of the caudal fin (*d n'*) are inserted. The upper edge of *n'*, and the lower of *h'* exhibit a rudimentary spine, no doubt the first indication of the rudimentary rays of each caudal lobe.

The ribs themselves or pleurapophyses (*pl*) are needle-like, a little curved, and diminish gradually in length backwards.

The interneural spines (*i n*) are variable in form, stouter under the first dorsal fin.

The interhæmal spines (*i h*) are more uniform.

The dermo-neural (*d n*) and dermo-hæmal (*d h*) spines, are all very much alike, the only difference consisting in the spiny or bony nature of those belonging to the first dorsal fin.

§ 3. COMPARISONS BETWEEN THE SKULLS OF DIFFERENT COTTI.

PLATE III. Fig. 6—21.

The skull of *C. viscosus* (Fig. 6—9) as described above (p. 14) must be recalled to mind in order to understand these comparisons.

The chief difference between *C. viscosus* and *C. Franklinii* (Fig. 10—13) consists in the fronto-orbital arcade which forms nearly a straight line along the declivity of the snout (Fig. 12). Besides, this region is a little shorter than the cranial box itself. The upper surface is likewise depressed, and the depression extends backwards on the occiput, so that the latter region appears more convex in *Cottus Franklinii* (Fig. 13). The cephalic channels of the lateral line are more developed than in *C. viscosus*; the upper view (Fig. 10) exhibits very plainly this difference by the reduced smooth surface in the middle, and the larger holes along the circumference. The acoustic capsule differs also in both of these species. We might even notice a difference in shape in the front of the vomer, which, in all the species, bears a narrow band of teeth.

In *C. Wilsonii* (Fig. 14—17), the fronto-orbital arcade is still lower than in *C. Franklinii*, and passes gradually to the upper surface of the skull without the slightest rising above it. This region again is of the same length as the cranial box itself. The upper surface of the skull is flat and perfectly even; being a little lower near the orbit than on the occiput; it has a slight sloping forwards (Fig. 16). This character will likewise be found on those species the external appearance of whose snout is rather elongated. Seen from behind (Fig. 17) the upper part seems more convex than it is in reality; this apparent convexity being given to it by the mastoid crests.

The front of the vomer is different both from *C. viscosus* and *C. Franklinii*. The acoustic capsules rise also more above the surface of the sphenoid.

Of *C. Richardsonii* (Fig. 18—21) we had only a small specimen to carry out our osteological comparisons. The skull resembles more that of *C. Franklinii* than any other; but the upper view (Fig. 18) shows the difference between the two species. In *C. Richardsonii* the form is subcircular, the width near the orbits being equal to that on the occipital region.

Thus we see that species which zoologically differ from each other most, such as *C. Franklinii* from *C. Richardsonii*, and *C. viscosus* from *C. Wilsonii*, are those in which the skull presents the least difference.

§ 4. COMPARATIVE OSTEOLOGY OF *COTTUS VISCOSUS* AND *ACANTHOCOTTUS VIRGINIANUS*.

PLATE III. Fig. 5—9 and 26—32.

Nothing is more alike than the general plan of arrangement of the bony frame in *C. viscosus* and *A. virginianus*. The differences must be sought for in the special structure of the regions, and in the preponderance of some of the bones, especially in those of the head.

In comparing the skull of *Cottus viscosus* (Fig. 6—9) with that of *Acanthocottus virginianus* (Fig. 26—29), the most striking difference is found to consist in the fronto-orbital arcade, which is much broader in the latter (Fig. 26) than in the former (Fig. 6). The snout is likewise more developed in *Acanthocottus*, the nasals occupying the whole space between the external projection of the prefrontals and the vomer. The turbinals in *Acanthocottus* are ossified, quadrifid, intimately connected with the prefrontals and nasals, and surmounted with a stout spine. The nasal spines themselves are partly concealed by the turbinals. The orbital rim rises above the middle smooth region of the arcade. A small spine directed backwards and outwards exists on the postfrontal, whence a ridge extends along the upper surface of the skull, to the supraoccipital, where a similar spine is seen. Thus the upper surface of the cranial box of *Acanthocottus* differs from that of *Cottus* by the presence of spines and ridges. The frontal region, however, is flat and smooth. The skull in *Acanthocottus* is proportionally more elongated; the orbito-frontal arcade and the snout together, much longer than the cranial box. The latter is also proportionally narrower near the orbits than on the occipital region. In height, the proportions do not differ much.

The vomer in *Acanthocottus* is provided along the medial line of its upper surface with a sharp carina extending to the whole length of that bone. Anteriorly there exists a pair of nearly vertical and approximated processes, behind which, and more apart, another pair is seen obliquely inclined backwards and outwards.

On the sides of the head there is the same number of bones, occupying the same relative position. As to their shape or form, some vary but very slightly, whilst others assume a quite different character. Thus the preopercular is provided with a very much elongated spine, stouter than the body of the bone itself. Immediately underneath, there is a second small but stout spine; both are directed

backwards. The lower and anterior extremity of the preopercular is terminated by an acute spine. The upper angle of the opercular terminates by a stout spine similar to that of the preopercular, although less powerful. The subopercular is provided with a slender and acute spine, directed upwards along the anterior edge of the opercular. Finally, the posterior extremity of the interopercular is very acute.

On the other hand, the suborbitals do not present any striking difference. The upper branch of the dentary is a little shorter than the lower one; the mucous channel of this bone is quite prominent. The horizontal branch of the premaxillary is a little longer than the vertical one. The hypotympanic is provided along its lower edge with a stout, acute and slightly curved spine, grooved underneath for the reception of the lower branch of the preopercular. The mesotympanic is entirely ossified, lying nearly horizontally above the hypotympanic spine.

The scapular arch and pectoral fins are similarly constructed in *Cottus* and *Acanthocottus*.

The position of the ventral fins is identical. The pubic bones alone differ somewhat in shape, being almost three-winged in *Acanthocottus*.

The vertebral column of *A. virginianus* is composed of thirty-six vertebræ, five more than in *C. viscosus*. Of this number twelve are abdominal, nine thoracic, and three pelvic, each bearing a pair of ribs; the pelvic vertebræ being provided as in *C. viscosus* with styliform pelvic bones directed obliquely backwards, the extremities of which are fixed to the hæmapophysal arch of the caudal vertebræ by means of ligaments. The caudal vertebræ are twenty-four in number, four more than in *C. viscosus*. The structure of the vertebræ themselves is very similar. In the first place the insertion of the ribs takes place in the same way, the anterior pair on the neural arch (Fig. 30), the posterior ones on the hæmal arch (Fig. 31), whilst the intermediate pairs are attached on the body itself of the vertebræ, at different heights. The pelvic appendages are not represented on Fig. 31; their position is the same as in *C. viscosus* (Fig. 5^d—a), immediately under the ribs. The sole difference is, that in *A. virginianus* the pelvic vertebræ have a complete hæmal arch, so that all the pelvic bones are inserted on it, whilst in *C. viscosus* the first pair is nearer the centrum, the hæmal arch of the ninth vertebræ being incomplete. Fig. 30 exhibits rudiments of parapophyses. A caudal vertebra is represented in Fig. 32, in order to show the neural canal somewhat different from that of *C. viscosus*. The neural arch and spine are more erect (Fig. 30), and the neural canal higher than broad; whilst in the caudal vertebræ (Fig. 32), this is broader than high, exactly the reverse of its structure in *C. viscosus*.

§ 5. THE BONY FRAME OF TRIGLOPSIS THOMPSONII.

PLATE II. Fig. 11; and PLATE III. Fig. 22—25.

The external delicate appearance of our fish is a direct reflex of its internal frame, which is composed of pieces of an extreme delicacy.

With reference to the general figure of the skeleton (Plate II., Fig. 11), we

ought to make the remark that the two posterior rays of the second dorsal have been omitted in the engraving, and thus it is not sufficiently near to the base of the caudal. The interhæmal spines are represented a little too much inclined, so that, while the anterior edge of the anal fin is correctly situated, the anterior interhæmal spine ought to abut against the first caudal vertebra, thus three vertebræ more backwards, instead of seeming apparently connected with the three pairs of pelvic appendages, the extremities of which alone should abut against the anterior interhæmal, leaving the latter behind them. The insertion of the ribs is more correct than in *C. viscosus*, although the anterior pair should come higher and reach the neural arch. The fins have been cut off from want of space.

The skull (Plate III, Fig. 22—25) exhibits that remarkable feature in the structure of the genus *Triglopsis* which reminds us of *Sciænoids*, and consists in the presence on the upper surface (Fig. 22), and on the face, of large mucus holes, communicating directly with the lateral line. The general form of the cranial box is elliptical, the upper surface smooth in the middle, flat, slightly dipping in front. On both sides the mucus channel is open from the paroccipitals to the post-frontals, into which it passes, until it meets its fellow of the other side, and takes with it a parallel course through the fronto-orbital arcade to the snout. In fact, that arcade is entirely transformed into a double channel whose walls are extremely thin and semi-transparent. The turbinals are in their respective place on Fig. 22; the nasals are not very conspicuous, and are covered in this case by the turbinals, which occupy exactly the same position as in *Acanthocottus* (Fig. 26), where the turbinals are also united to the upper part of the snout. The cranial box itself is so thin as to shrink in drying when all soft parts, internal and external, are removed. The lower surface (Fig. 23) is very smooth; the acoustic capsules are proportionally large, although not very conspicuous on the figure, as they had shrunk since they were prepared for the purpose of being drawn. In the profile view (Fig. 24) the proportional length of the cranial box and the orbito-frontal arcade is very obvious; the former being shorter and less elevated near the orbit than on the occipital region.

A character belonging to the *vomer* (12) and which may vanish away during the preparative process of the skull, is represented on Plate II, amongst the movable bones of the head. This consists in the presence on the anterior and median line of that bone, of a narrow elliptical band of teeth similar to those which exist on the front of the same bone.

The *premaxillary* (22) has the general appearance of an open triangle; its ascending branch is shorter than the horizontal one; and terminates in a point, behind which there is a flat and much shorter process. The horizontal branch is likewise expanded, although the very tip terminates in an acute angle. The *maxillary* (21) is an elongated and curved bone, narrow on its middle, provided in front with a trifid articulating head, whilst its posterior extremity is flattened, truncated, and movable into the membrane which forms the angle of the mouth.

The *palatine* (20) is provided posteriorly with a needle-like spine which extends backwards in contiguity with the styloform pterygoids. The *entopterygoid* (23) is blade-shaped and has the transparency of the thinnest membrane. The *pterygoid*

(24) is pointed forwards and triangular posteriorly. The *dentary* (32) is remarkable for its broad lower branch entirely hollow; the upper branch which bears the teeth is scarcely more compact, and a little shorter. The teeth themselves are exceedingly small and slender. The *articular* (29) participates in the broadness of the dentary, is hollow like the latter, and provided with two spiny processes. The *angular* (30) is a small scaly bone of little importance. The *splénial* has escaped our notice; whether removed in preparing the skeleton, or entirely wanting, we are not prepared to tell. To judge of it from its appearance in *C. viscosus*, it would play no important part in the structure of this region. The *hypotympanic* (28) is bifid on its posterior angle, and provided with a comparatively stout lower branch. The *pretympanic* (27) and *mesotympanic* (26), which fill up the space between the concavity of the preopercular behind, the hypotympanic underneath, the pterygoids in front, and the epitympanic above, are almost membranous. Their shape on the figure is rather ideal, as they had shrunk a few hours after preparation, so as to become shapeless. The *epitympanic* (25) is everywhere so characteristic as not to be mistaken. It is provided with similar articulating heads or processes as in *C. viscosus*, and connected with the same bones.

The *preopercular* (34) constitutes one of the characteristic features of this genus. Its shape is as usual, crescentic; a broad channel passes through its centre, and the posterior edge, or else the convexity of the crescent is furnished with four spines or rather four acute processes, thinner, if possible, than the body of the bone itself. The two superior spines are directed obliquely upwards, the uppermost is the largest; the two inferior ones, very minute, are directed downwards. The *opercular* (35) is comparatively small, semi-membranous, uniform, and spineless. The *subopercular* (36) and *interopercular* (37) are likewise semi-membranous, very small and uniform; their shape is accurately figured.

The lateral line in *T. Thompsonii* (Fig. 11, *l l*) acquires a very great development. When the skin is removed it appears like a uniform tube, cartilaginous in its structure, exhibiting along the exposed sides, a series of very large holes, which correspond to the external pores of the skin. It can be separated from the lateral muscle in an unbroken chain (*l. l.*) from the tip of the caudal, where it terminates, to the mastoid groove, where it is attached. Here it passes into the head and from the mastoid groove a transversal supraoccipital canal establishes the first communication between the right and left. The suprascapular forms an arch or bridge under which the lateral line proceeds forwards. When in front of the suprascapular the channel is covered by the scale-shaped *supramastoid* (8'). A more considerable branch runs into the preopercular, passing through the *supratympanic*, a tubuliform bone, which was not preserved on the specimens at our command. From the preopercular, the channel passes into the articular, and thence into the lower jaw, or dentary. In advance of the supratympanic tube, and horizontally, we have the *supralachrymals*. The *lachrymal* (73) which limits the posterior edge of the orbit is soldered to the posterior *suborbital* (73') thus forming a channel which from the supralachrymal tubes, passes under the eye and into the *turbinal* (19) situated above the snout. From the supralachrymal tube an upper branch of the channel passes into the postfrontals towards the orbito-frontal arcade, and through

the latter into the nasal cavity, thus meeting the suborbital branch on the snout. The *supraorbital* we were at a loss to find.

The hyoidean apparatus is composed of the usual bones. The small *stylohyal* (38) is nearly straight; the *epihyal* (39) subtriangular, bearing two branchiostegals. The *ceratohyal* (40) is the longest, and attached to it are the four remaining branchiostegals. The *basihyal* and *glossohyal* are seen, one in front, the other above the anterior extremity of the ceratohyal. The *urohyal* (43) is provided with an elongated membranous appendage underneath. The *branchiostegals* (44) are cylindrical and slightly curved.

In the branchial arches, the small *basibranchials* (45) are scarcely to be distinguished, this series of bones forming a cartilaginous band in the midst of which minute surfaces of ossification alone are discernible. The *hypobranchials* (46) are independent from each other, short, thin, and flattened, varying somewhat in shape. The *ceratobranchials* (47) are very slender, slightly convex, provided on both sides and inwardly with little tubercles beset with extremely minute teeth. The *epibranchials* (48) are the most variable of all the bones constituting an homonyme series. The *pharyngobranchial* (49) is subquadrangular, the entire exposed surface of which is covered with minute teeth. The *inferior pharyngobranchials* (49') are elliptical and beset with teeth similar to those of the pharyngobranchials.

The *suprascapular* (50) is as usual, situated above the paroccipito-mastoid groove; but its centre is hollow. The *scapular* (51) is subtriangular, thin and flat. The *coracoid* (52) is likewise very thin, flattened upon different planes, and crescentic. The *epicoracoid* (58) is styliform and a little longer than represented on the figure. The *ulna* (54), the *radius* (55), and the *carpals* (56), are altogether in a cartilaginous state. The ulna and radius are contiguous and form a band along the coracoid, thus preventing the carpals from coming into contact with the latter. The carpals themselves are surrounded by a thin semi-membranous edge, on which the *metacarpophalangeals* (57) articulate.

The ventral fins are connected with the lower part of the scapular arch. The *pubic bones* (63) are subtriangular, furnishing posteriorly a point of attachment to the *metatarsophalangeals* (70). The external and shorter one is bony and unjointed, whilst the three remaining ones are soft and jointed.

The vertebral column is composed of thirty-nine vertebræ, twelve of which belong to the abdominal region, and twenty-seven to the caudal. Accordingly, there are twelve pairs of ribs corresponding to the twelve abdominal vertebræ, three of them being provided with pelvic appendages. The centrum is circular; the vertical diameter of the middle of the body of the vertebræ, however, is greater than the transverse. The neurapophyses and hæmapophyses generally are quite uniform, slender, and little prominent. The neural spines (*ns*) are scarcely apparent on the anterior thoracic vertebræ (1, 2). The same enlarged figures exhibit the peculiar shape of the neural arch seen from behind (1) and in profile (2), together with the insertion of the ribs (*pl*). The numbers 1 to 12 appended to the vertebræ do not indicate their rank in the series. Numbers 3 to 12 are of natural size, and were intended to illustrate their special structure all along the column; but the figures are altogether too small. Numbers 1, 2 and 3 belong to the thoracic

region. The enlarged one (1, 2) is the sixth; whilst number 3 is the second. The numbers 4, 5 and 6, are pelvic vertebræ; and 7 to 12 belong to the caudal region.

The first pelvic vertebra (4) shows the first traces of hæmapophyses; the second and third (5, 6) have a complete hæmal arch on the base of which the pelvic appendages (4) are inserted. The hæmal arches of the caudal vertebræ, as well as the hæmal spines (*h s*) are but little developed. The hæmal spines are soldered with the arches. The neural and hæmal arches and spines are flattened near the tail. The caudal plates (*n' h'*) of the last vertebra (12) are subtriangular and elongated; the uppermost lined with a few rudimentary rays.

The ribs or pleurapophyses (*pl*) are slender, flexible, elongated, and curved, needle-shaped spines. The anterior pair is fastened to the scapular arch.

The interneural and interhæmal spines are uniform, elongated and slender, differing scarcely from the ribs themselves.

§ 6. TRIGLOPSIS THOMPSONII COMPARED WITH COTTUS VISCOSUS, AND WITH ACANTHOCOTTUS VIRGINIANUS.

The plan of structure of the bony frame of the three genera of Cottoids which we have had an opportunity of examining, is identical in its main features.

The general form of the skull of *T. Thompsonii* resembles more that of *A. virginianus* than that of *C. viscosus* or any other species of Cottus. The chief difference consists in the absence of spines, and in this respect *T. Thompsonii* comes nearer to *C. viscosus* than to *A. virginianus*. The turbinals in the latter are strong and spiny, whilst in the two others these same bones are weak, thin, scaly and deprived of spines. The cephalic channels of the lateral line are identical in the three genera, but reaches its maximum of development in Trigloopsis, whilst it is much less apparent in Cottus and Acanthocottus. The suborbital series is the same in the whole group, only a little modified in the shape of its constitutive pieces and their degree of union. The hyoidean and branchial arches are identical. The opercular apparatus assumes differences by which the genera may be distinguished. In *T. Thompsonii* the preopercular is provided with four needle-like spines, short and flexible. *C. viscosus* has only one well-developed spine, whilst in *A. virginianus* besides the stout spines of the preopercular, we see the opercular, the subopercular, the interopercular, and the hypotympanic, provided with similar spines; the mesotympanic and pretympanic are also more compact, and better defined in the latter species.

The scapular arch has the same general structure; but in *A. virginianus* the angles of the suprascapular and scapular are more acute and spine like; in *T. Thompsonii* the ulna and radius coalesce, thus establishing a separation between these bones and the coracoid.

The ventral fins in the three genera have the same position under the head and the same connection with the scapular arch. The pubic bones articulate together

into a triangular piece which penetrates forwards above the union of the coracoids. There exists in all, an external and unjointed ray with three or four jointed ones.

The number of the vertebræ varies in the different genera according to the length of their body. That number even varies amongst the different species of the same genus. But the centrum of the vertebræ themselves is very much alike in all Cottoids. The axis of each vertebra is provided with a minute hole, thus establishing a direct communication through the centre of the vertebral column, from the occiput to the tail. The shape of the neural canal is subjected to some variation, according to the greater or less development of the neural arches and neural spines.

The ribs, or pleurapophyses are identical in form, structure and position in *T. Thompsonii*, *C. viscosus*, and *A. virginianus*. Their absolute number may vary according to similar variations in the number of abdominal vertebræ. As far as our investigations go, we found constantly three pelvic vertebræ, calling by that name such vertebræ as are provided underneath the ribs with rib-shaped, or styli-form bones, of which there are constantly three pairs, bent backwards and kept within the muscular wall of the pelvis. In the figures of *C. viscosus* and *T. Thompsonii*, they are represented hanging down, in order to render them more conspicuous. The caudal vertebræ, again, are liable to some variation in number.

The interneural, and interhæmal spines, as well as the dermo-neural and dermo-hæmal ones, present the greatest similarity in the whole group.

§ 7. THE ENCEPHALA OF *COTTUS VISCOSUS*, *C. GRACILIS*, *C. GOBIOIDES*, *TRIGLOPSIS THOMPSONII*, *ACANTHOCOTTUS VIRGINIANUS*, AND *A. VARIABILIS*, COMPARED.

PLATE III. Fig. 33—48. (Figs. 36—45 are represented twice natural size.)

In the genus *Cottus* the brain or encephalon fills up the whole cavity of the skull, the upper roof of which is almost in contact with the upper surface of the encephalon, which can be seen through the frontal bones, as soon as the skin is removed. The layer of cellular fat is consequently very thin, as the space itself is exceedingly reduced.

In the genus *Acanthocottus*, the cavity of the skull would contain a brain twice as large. The space all around, is occupied by cellular fat filling up completely the entire cavity. When the upper roof of the skull is cut off the encephalon is not exposed unless that fat is removed.

In the genus *Trigloopsis*, we have an intermediate stage; the cavity of the skull is still larger than the bulk of the encephalon and the remaining space filled by a similar fat.

If we were to establish a series, we would not hesitate in placing *Acanthocottus* below, next *Trigloopsis*, and *Cottus* above.

But let us now glance at the brains themselves, and see how far they can be available in comparative zoology.

The different regions of the encephalon are closely grouped together. There exist no rhinencephalic crura carrying off the rhinencephala or olfactory lobes at a certain distance from the prosencephala. The rhinencephalic lobes are brought

into close contact with the prosencephala, sometimes partly overlapped by the latter (in *Cottus viscosus*, *gracilis*, and *Acanthocottus variabilis*) and sometimes entirely exposed (in *Cottus gobioides*, and *A. virginianus*). The proportional development of the prosencephalon and mesencephalon varies in both *Cottus* and *Acanthocottus*; the former, always larger than the latter, acquires a greater proportion in *C. viscosus* and *gracilis* than in *C. gobioides*, and in *A. variabilis* than in *A. virginianus*.

Thus, so far, we have no generic difference in the encephala of *Cottus* and *Acanthocottus*. Indeed we have not investigated in that respect the whole range of species, and perhaps characters will hereafter be detected.

The encephalon of *Trigloporus* is more characteristic; its longitudinal axis is proportionally greater than in both *Cottus* and *Acanthocottus*, a character which we might have anticipated in comparing the structure of the skull and the external appearance of the head.

The most interesting result which we have derived from the study of the brains of *Cotti* is the fact that differences are found between the species which we had established, guided chiefly by zoological characters, sometimes most minute.

If we compare the encephalon of *C. viscosus* (Fig. 43—45) with that of *C. gracilis* (Fig. 39—41) we find a cerebellum of nearly the same size and form; but the mesencephalic or optic lobes are oblong in the former, and circular in the latter. The prosencephala differ most: irregularly triangular in shape in both species, their surface in *C. viscosus*, is raised into three nearly equal hillocks, one at each corner. In *C. gracilis* we perceive only one tubercle-like elevation, situated at the outer and posterior angle, whilst the inner edge of the prosencephalon forms a uniform, longitudinal ridge, the posterior extremity rather projecting beyond and between the mesencephala.

The rhinencephala in both species are partly covered by the prosencephala, and a little more so in *C. viscosus* than in *C. gracilis*. The medial line of separation between these two lobes is rather indistinct on the figure of *C. viscosus* (Fig. 43). The hypoaria in both species do not differ much, but the hypophysis in *C. viscosus* is smaller, circular and quite distant from the hypoaria and hæmatosac, whilst in *C. gracilis* the hypophysis is oblong, partly incased between the hypoaria and close to the hæmatosac.

Behind and between the hypoaria there exists an odd, very small lobe, a little more conspicuous in *C. viscosus* than in *C. gracilis*. That lobe does not exist in the two species of *Acanthocotti* figured on our plate, whilst in *Trigloporus* it acquires a development greater than the hypoaria themselves.

In *Cottus gobioides* (Fig. 42) the prosencephalon is irregularly quadrangular, very uniform above and proportionally smaller than in the two preceding species. The mesencephalon is oblong as in *C. viscosus*, and the cerebellum circular, more like that of *C. gracilis*. The rhinencephalic lobes are not completely exposed in advance of the prosencephala. In its general feature it resembles more *A. variabilis* (Fig. 46) than either of the true *Cotti*. The want of materials, and especially of recent specimens, has prevented our making a more complete study of it as well as of our giving a better illustration.

The difference between the encephala of *A. variabilis* (Fig. 46—48) and *A. virginianus* (Fig. 33—35) are so obvious that they need scarcely to be pointed out. As usual, the cerebellum varies but little. The mesencephalon is elliptic in the former and ovoid in the latter. The prosencephalon of *A. variabilis* is uniform above, whilst in a *A. virginianus* it assumes a character similar to that of *C. viscosus* with this difference, that the posterior and inner hilly protuberance acquires a much greater development, and seems to absorb the two others. In advance of the prosencephala the pyriform rhinencephalic lobes are seen completely exposed and free. The same lobes are in close contact and slightly overlapped in *A. variabilis*. The hypophysis in *A. virginianus*, is exceedingly small compared to its size in *A. variabilis*, where it is greater than the hypoaria, on which it encroaches considerably. It is regularly oblong shaped.

The encephalon of *T. Thompsonii* may readily be distinguished from that of either Cotti or Acanthocotti. The epencephalon exhibits a more prominent swelling on the sides of the medulla oblongata. The cerebellum and mesencephala are subcircular, the latter resembling most those in *C. gracilis*. The prosencephalon is proportionally much more developed than either in Cotti or Acanthocotti, and appears also more separated from the mesencephalon. At the inner and posterior edge, a circular swelling exists, looking like a smaller pair of lobes superadded on that region. The rhinencephalon is so much overlapped that it is only apparent in the view from underneath (Fig. 37). The hypophysis is of medium size, situated in advance of the mesencephalic lobes. The hypoaria seem rather secondary in importance; they are absorbed by the development of a medial lobe faintly indicated in *C. viscosus* and *gracilis*, behind and below the hypoaria. In *T. Thompsonii* the medial lobe is larger than the hypoaria themselves, which are partly covered by it. The hæmosac is seen above, overlying the anterior portion of the medial lobe. Immediately in advance of the hæmosac, on the hypoarian floor, a small spherical swelling is slightly indicated, and surrounded in front by a ridge delineating the anterior limit of this floor.

Without having contemplated the comparative study of the cephalic nerves in this memoir, we have allowed them to be represented in the case of *A. variabilis* (Figs. 46—48), in which we had a fair chance to observe them. This may be interesting to anatomists, who might wish to compare their development and distribution with that of other groups.

§ 8. THE MUSCULAR SYSTEM OF *COTTUS VISCOSUS*.

PLATE III. Fig. 1—4.

It has been shown by recent labors that the fleshy mass which extends from head to tail, all along the sides of the body of fishes, does not constitute a single muscle (the so-called *lateral muscle*), but is actually composed of a series of vertical muscles, the vertical flakes or segments, which correspond generally in number to that of the vertebræ. These flakes or segments (*myocomma*), extending from

the dorsal line down to the ventral line, are characterized by inflexions or curves, forming sometimes gentle undulations and sometimes angles more or less acute.

Now these angles, these curves, delineate organic regions in the body, and, having satisfied ourselves that a wide field of inquiries and philosophical deductions is connected with the morphology of the muscular system, we did not hesitate in giving figures of the general appearance of the fleshy parts in a species of the genus *Cottus*. If, instead of reproducing over and over the same figure, anatomists had given us each time another, we would possess now very important data for the understanding of the muscular masses, not only in the class of fishes but also in vertebrata generally. Fishes, reptiles, birds, and mammals being constructed upon the same plan, there is a morphology to be traced throughout those four classes; and, besides, each class has to be thoroughly investigated in this respect.

As we are not prepared, on account of the scarcity of materials, to say anything general on the class of fishes, and as it is not within the limits of this work to enter into such inquiries, we shall limit ourselves to a mere sketch of our views.

In *C. viscosus* (Plate III. Fig. 3), the muscular flakes of both sides are seen to meet along the back under the shape of an acute angle directed backwards, indicating the *dorsal line*. The *region of the back* is indicated by another bending of the flakes forwards. The next curve, the convexity of which is directed backwards, takes place on the line of separation of the back and abdominal region (Fig. 1). The *abdominal region* itself is marked by a very open curve, convex forwards, extending down till another smaller curve appears, separating the abdominal from the *ventral region* on which the flakes gently undulate (Fig. 2).

On the tail, or *caudal region*, the bending of the flakes is more uniform than on the trunk; but the tail, it must be remembered, is a mere appendage, although an organic region too. This region is always much developed in osseous fishes as well as in many cartilaginous, continuing the trunk backwards. In some cartilaginous fishes, it is very slender and filiform. In some reptiles it vanishes completely; in birds it is most diminished, and in many mammals it reappears under a very disproportionate shape, whilst in others it again loses its importance. The muscular system of that region is accordingly liable to corresponding variations.

The morphology of the caudal region constitutes no serial law, whilst the morphology of the muscular flakes, along the trunk in fishes and the localization of the muscular masses in the other classes of vertebrata, will illustrate an organic gradation.

The fins and rays are put into motion by sets of muscles independent of the flakes, the description of which cannot find any place here. We would only glance at the branchiostegal apparatus (Plate III. Fig. 4), the rays of which are distended or retracted by transversal, thin muscular bands, attached above at the inner surface of the opercular, uniting below with the transversal fibres of the isthmus. Fig. 2 also exhibits the general outline of the glosso-hyoidean muscle, much developed in Cottoids.

Between the skin and the flakes there exists a thin layer of muscular fibres, the muscles of the skin. In *C. viscosus* they cover completely the flakes all along the region of the back, the fibres running from one side to the other in passing unin-

errupted between the rays of the dorsal fins. The same is observed on the lower part of the tail from the anus to the caudal fin. On the abdomen and belly the layer is so thin that the flakes are exposed as soon as the skin is removed.

§ 9. THE SKIN AND THE LATERAL LINE IN COTTOIDS.

The skin in Cottoids is generally scaleless, and, in most cases, smooth. The Hemilepidoti of the marine tribe constitute the single exception, and even here they exist merely in bands or patches scattered over the body. The fresh-water species, however, are absolutely scaleless.

In several Cotti, the skin on the thoracic region is beset with very minute asperities, perceptible only to the touch when the finger is passed from behind forwards.

On examining under the microscope the skin overlying the head of Cotti, we observe in its thickness small irregular star-like ossifications which are more developed in *Acanthocotti* so as to become sensible both to the touch and naked eye. In *Trigloopsis*, the skin does not, even under the microscope, exhibit anything in its muscular texture; whilst in *Cottopsis* its whole surface is prickly from head to tail. There can be no doubt that those prickles are the same parts which we observe on the thoracic region of Cotti, only in *Cottopsis* they assume their maximum of development. Not having the opportunity of examining their structure in *Cottopsis*, we cannot venture any opinion as to their signification; whether the homologues of true scales or a production of the skin peculiar to fishes unprotected with scales.

The lateral line in Cottoids has a very remarkable structure, which could hardly have been suspected had the discovery of the genus *Trigloopsis* not been made. Its beauty and development in the latter is such as to leave no doubt that it forms a regular, cartilaginous tube, with a series of quite large openings outwards (Plate II, Fig. 11, *ll*) communicating through a corresponding series of pores of the skin, with the surrounding medium. The removal of the skin exposes this tube, which still adheres to the sides by the layer of dermic muscles; after this layer is removed, the cartilaginous tube may be detached from the tail forwards, where it is seen to be united with the head. It passes through a channel of the occipital bones, sending down a branch along the preopercular, into the lower jaw. Proceeding forwards it branches off again in advance of the orbit, one branch running along the upper edge of that cavity into the nostrils, the other following its lower edge through the chain of suborbital bones into the nostrils also.

That the lateral line in *Trigloopsis* is intended to supply water to the system, there can be no doubt; and as little, that it answers the same end in other fishes. Its structure may be diversified according to the natural groups; this constitutes its morphology; but its philosophic meaning is the same throughout the whole range of the class.



§ 10. THE ALIMENTARY CANAL, URINARY BLADDER, AND OVARIES, IN COTTOIDS.

Knowing the animal diet of Cottoids, we may expect a narrow and short alimentary canal. Its entire length from the pylorus to its posterior opening does not exceed the length of the trunk, the head and caudal fin excluded.

On exposing the splanchnic organs by the removal of the walls of the abdominal cavity, from below, the liver is seen occupying the anterior and left portion of that cavity, covering completely the stomach, whilst the right portion is occupied by the winding of the intestine. Posteriorly are the ovaries, a right and a left, which when containing eggs fill up the cavity in that region, leaving a narrow passage to the intestine along the medial line of the belly.

In *Cottus viscosus* the general form of the stomach is subcircular, or rather elliptical. The cardia is proportionally prominent and directed forwards, at the termination of which, and around the pylorus, are four elongated, pyloric, nearly equal appendages. Here the intestine runs backwards, then forwards again, and finally takes a straight course towards the vent, thus bending twice upon itself. Its anterior half is much broader than the posterior one.

In *Acanthocottus virginianus* and *Trigloporus Thompsonii* it differs but little; the pyloric appendages of *Acanthocottus* are proportionally much shorter and thicker, and variable in length.

In *Trigloporus* these appendages are seven in number, six developed ones nearly equal in size, intermediate in length between those of *Cottus* and *Acanthocottus*, and a rudimentary one. The pyloric appendages present some variations which make scattered observations very uncertain when used in the characterization of the groups.

The urinary bladder is very thin, pyriform, or elongated, situated above the ovaries. Cottoids have no air bladder.

The kidneys are so close together that they seem to constitute a single organ, slender and elongated in shape; they extend nearly to the two-thirds of the abdominal cavity adhering to the vertebral column.

The ovaries are pouch-like bodies, having a common duct. Sometimes after the spawning season, when they are reduced to their smallest size, they appear then under the shape of two elongated and cylindrical processes, differing only from the urinary bladder, by the thickness of their walls. When expanded by the development of the eggs, the walls become so thin and transparent that their contents may easily be seen. In this state these organs are elliptical.

At the upper wall of the ovarian sac there exist membranous folds in which the eggs are developed; the lower wall remains free from any such folds. When the eggs are mature, and ready to leave the body, they separate from these folds; but instead of dropping into the abdominal cavity, as is the case with many fishes, they are kept in the ovarian pouch, which leads into the single oviduct, whose opening is placed behind the vent.

The eggs themselves are very large compared to the size of the fish.

The spermaries are very slender, much elongated, extending from the oesophagus

to the posterior part of the abdominal cavity. They not only differ from ovaries by their shape, but also by their color, which is generally deep brown, contrasting with the yellowish appearance of the ovaries.

§ 11. RESPIRATORY APPARATUS.

This apparatus is composed of four branchial bony arches provided upon their convexity, with respiratory fringes in full activity. A fifth rudimentary row of fringes may be seen within the thickness of the membrane lining the inner wall of the opercular; but these fringes are not free and take no part in the aerification of the nutrient fluid. On each side, and internal to the fringes, there is along the concavity of the arches, a row of tubercles covered with minute card-like teeth, perhaps only needle-like asperities, for they are not inserted on the tuberculous bone, but belong to the overlying membrane, to which they adhere when the latter is removed. The inner arch possesses only one row of these tubercles, being united to the hyoidean apparatus by a membrane which leaves to the arch but little motion.

CHAPTER III.

ON THE GENUS COTTUS, Artedi.

§ 1. ZOOLOGICAL CHARACTERS.

RESTRICTED within the limits which we have assigned to it,¹ the genus *Cottus* still comprehends a considerable number of species which, although apparently cast in the same mould, are nevertheless distinct, as will, we hope, appear from their descriptions and figures.

The characters of the genus consist in the presence on the preopercular of one spine only, which is situated at the posterior angle of that bone, and is curved upwards and backwards. Sometimes a much smaller spine is to be found beneath, and in one instance there is a third one of the same size as the second, directed downwards. The inferior edge of the subopercular is also provided with a similar minute spine, having its point directed forwards, and generally completely concealed under the skin and muscles. The head consequently has a smooth appearance which contrasts singularly with the spiny head of *Acanthocottus*, or marine *Cottus* of authors. The mouth is but little cleft, and its angles seldom extend beyond the anterior rim of the orbit. The lips which line the jaws are capable of more or less expansion along the branches of the jaws, and at the angle of the mouth. The premaxillaries, the dentaries and the vomer, are the only bones provided with truly characterized, although very small, card-like teeth. In their immature state some species exhibit teeth-like asperities on the palatines. This occurs chiefly amongst those having four jointed rays to the ventrals: in *C. Wilsonii*, *C. Bairdii*, and *C. meridionalis*. *C. gracilis* is the only one of the division with three jointed rays, where similar asperities have been noticed. This character of palatine teeth, which is merely shadowed in the genus *Cottus*, acquires a full development in other genera, thus constituting a permanent feature and assuming an actual signification.

The eyes are situated near the summit of the head, more or less approximated on the frontal line. There are constantly two nasal openings; a tubular one, placed along the space comprised between the anterior border of the eye and the extremity of the snout; the other is even with the surface of the skin and situated backwards, behind and above the former and very close to the orbit. The latter opening has been but recently discovered, having generally been overlooked on

¹ Proc. Bost. Soc. Nat. History, iii. 1851, p. 183.

account of its minuteness. In *Acanthocotti*, however, it is quite large and easily distinguishable.

The body is smooth and deprived of scales; it is more or less viscous or slimy, as all fishes generally are. It diminishes gradually in thickness and in height from the head towards the tail. The back is almost straight or slightly arched. The lateral line exhibits in its structure a peculiarity which seems to belong chiefly, if not exclusively, to all the American species. The subcutaneous cartilages disappear on the last fourth of the line, whence it is continued to the base of the caudal fin by a series of minute pores, subjected to a sudden fall on the peduncle of the tail. This character had already struck Mr. Heckel, who makes of it the distinguishing mark of his *C. gracilis*, the only American species of which he saw specimens.

Another character, more or less general, making a distinction between the species of the two hemispheres, is the fact that the rays of the fins have a tendency to be more bifurcated in the species of the old hemisphere than in those of the new. As far as the rays of the pectoral fins are concerned, we know only one American species, the *C. Wilsonii*, in which the upper ones are subdivided. Except in *C. Richardsonii*, where we have noticed some rays of the centre of the second dorsal as showing a slight bifurcation at their summit, we are not aware of any other fin where that character of the bifurcation of the rays exists, except in the rays of the caudal fin generally, although in a less degree than among the European species.

The first dorsal fin is always lower than the second; sometimes continuous with the latter by a membrane, sometimes completely separated by a short interval. The length of the pectorals varies according to the species; their inferior rays are shorter and thicker than the upper ones, and their tips extend beyond the membrane which unites them, giving to the lower edge of the fin a scalloped appearance.

There is, in the structure of the ventral fins, a peculiarity worthy of notice, and which will undoubtedly have a great weight upon the question of the validity of the species in this genus. In some there are four soft and articulated rays, whilst others have but three, all of them possessing the anterior short and spiny ray, closely connected with the first soft one and hidden in the thickness of the skin. Now the European species, mentioned by Mr. Heckel, are all provided with four soft rays to the ventrals, and this also must have struck him as an interesting fact, since the presence of three soft rays constitutes the second character by which he distinguishes his *C. gracilis* from all others. The study of the American species has taught us that this character had more than a specific value; and, in consulting the various documents respecting the history of European species, we became satisfied that the same was the case with regard to these latter. Some may suppose this character to be sexual, but we are convinced that it is not the case, having had this question before us from the very commencement of our investigations. Having had series of individuals, young and adult, of most of the species, we always found it constant. Six species have four soft rays: *C. cognatus*, of Great Bear Lake; *C. Richardsonii*, of the northern shore of Lake Superior; *C. Alcockii*, of Lake Huron; *C. Bairdii*, of the north-western tributaries of the Ohio; *C. Wilsonii*, of the south-eastern tributaries of the same river; and *C. meridionalis*, from James River (Va.). Now, if we have to deal with a sexual character, we

ought at least to find both sexes in the same hydrographical basin. But, along the southern and eastern shores of Lake Superior, we find the *C. Franklinii*, which inhabits the same basin as *C. Richardsonii*, and, even if both of these species were provided with the same number of rays to the ventrals, nobody would ever think of uniting them in one, so much do they differ in other respects.

If we take up the species with three soft rays only to the ventrals, we witness similar phenomena. Without speaking of *C. Fabricii*, which we have not had under actual examination, we find, in the same latitude, *C. gobioides* in the waters running west of the Green Mountains, and *C. boleooides* east of the same orographic range. Should the streams in which they live have a direct communication, a zoologist could not reasonably identify them. Finally, *C. viscosus* which inhabits eastern Pennsylvania, and *C. gracilis*, Connecticut, New York and Massachusetts, are widely distinct. The two species which resemble each other most, *C. viscosus* and *C. Franklinii*, are geographically the most remote.

It is not improbable that some one may hereafter propose to unite in a separate genus the species provided with four soft rays to the ventrals. Our impression, however, is, that such a generic subdivision would be useless, inasmuch as it would interrupt the philosophic idea to which we have been led by our investigations. Indeed, a genus, in our mind, is a group varying, it is true, as to the number of species which it may contain, but having, at the same time, a physical and a metaphysical signification. A genus involves a progressive idea whose realization is materially carried out in the species. Now we are at loss to find what progress is involved in the fact that some species have one ray more or less to the ventral fins. These two facts are cotemporaneous, and their value is entirely in the discrimination of the species, and, indeed, in this respect they have an actual signification in the manner in which they are distributed among them.

The same peculiarity is observed amongst *Acanthocotti*, and those also would have to be likewise subdivided. If the characters of three or four soft ventral rays were of a generic value, either the species with three or those with four should have appeared first in geological times.

The color in *Cotti* has not yet afforded any safe distinctive mark between the various species. The ground is generally brownish-yellow, sometimes blackish-brown, maculated and dotted with a deeper black or brown. The upper edge of the anterior dorsal in *C. viscosus* is orange, whilst in *C. gracilis* it is red. Whether that hue is specific needs still to be investigated, as well as its particular appearance in the other species of the genus.

The following synoptical table will exhibit the most prominent differences between the species of the genus *Cottus* :

COTTI	With five rays to ventral fins.	Body fusiform, elongated.	Origin of anal fin opposite to third ray of second dorsal. Pectorals shorter than the head. Vent placed midway between snout and tip of caudal fin.	C. RICHARDSONII.
			Origin of anal fin opposite to sixth ray of second dorsal. Pectorals of same length as head. Vent nearer to snout than to base of caudal fin.	C. COGNATUS.
			Upper rays of pectorals branched; their tip extending to anterior margin of second dorsal. Insertion of ventrals in advance of first dorsal.	C. WILSONII.
			First dorsal very low. Tip of pectorals extending beyond the anterior margin of anal. Insertion of ventrals opposite to the first ray of anterior dorsal.	C. BAIRDII.
	Body stout and short.		A second very minute preopercular spine. Origin of anal opposite to third ray of second dorsal. Tip of pectorals extending beyond the anterior margin of the second dorsal and anal. Insertion of ventrals near the lower edge of pectorals in advance of anterior dorsal fin.	C. ALVORDII.
			A second and third, exceedingly minute, preopercular spines. Origin of anal opposite to fourth ray of second dorsal. Tip of pectorals not reaching the anal fin. Insertion of ventrals even with the lower edge of pectorals in advance of the first dorsal fin.	C. MERIDIONALIS.
		Body fusiform and slender.	Base of pectorals crescentic; their tip extending beyond the fifth ray of second dorsal and third of anal fins. Insertion of ventrals in advance of the anterior dorsal, near the lower edge of pectorals.	C. BOLEOIDES.
			A second minute preopercular spine. Tip of pectorals not reaching the anterior margin of second dorsal. Base of pectorals crescentic. Dorsal fins separated by a free space.	C. FORMOSUS.
			Base of pectorals crescentic; their tip extending beyond the fourth ray of second dorsal and first of anal fin. Insertion of ventrals under the pectorals and in advance of anterior dorsal.	C. GRACILIS.
			Base of pectorals slightly curved; their tip not reaching the anterior margin of second dorsal. Insertion of ventrals in advance of anterior dorsal and under the middle of pectorals.	C. FRANKLINII.
	With four rays only to ventral fins.	Body cylindrical, or subcylindrical and stout.	Base of pectorals crescentic; their tip not reaching the anal fin. Insertion of ventrals under the upper edge of pectorals.	C. GOBIOIDES.
			Base of pectorals straight; their tip not reaching the anterior margin of anal. Insertion of ventrals behind the base of pectorals, and in advance of the anterior dorsal.	C. VISCOSUS.
			Head subtuberculous; region behind the eyes and lateral line, rough.	C. FABRICII.

§ 2. CHRONOLOGICAL SUMMARY OF THE HISTORY OF AMERICAN COTTI.

Before entering into the descriptions of the species of this continent, a rapid glance at their chronological history is deemed here in place.

The most ancient document which exists relating to this subject, as far as we know, goes as far back as the first half of the eighteenth century.¹

"The *Barbuts*, or *Miller's Thumbs*," says the writer, "are the very same here as those in England and other parts of Europe. They are about three or four inches long, have no scales, and the back is yellowish, with a few little black spots. The head is large, and the mouth wide and round. Out of the fins grow several sharp prickles or thorns, especially in those near the head. These fishes are very plenty in rivers and creeks, near the sea shore, where they feed on watery insects (p. 242)." The figure given of the fish is insignificant, and can be of no use in determining its characters. We cannot help thinking that the individuals mentioned as occurring in creeks near the sea shore are the young of *Acanthocottus virginianus*, which when three or four inches long, have a striking superficial resemblance with *Cottus* proper. For, the Cotti or *Miller's Thumbs*, keep off the sea shore and salt waters generally. As to the individuals found in rivers, we believe that they belong to the genus *Cottus*. But the species to which they must be referred we are not prepared to decide, as we have had no specimen on hand for direct comparisons. That they are different from the English ones, cannot be doubted for a moment, judging the question *à priori*, and comparatively with the facts with which the study of those fishes has made us acquainted. They will have to be carefully compared first with *C. meridionalis* from the tributaries of James River, especially if the ventrals should be composed of four jointed and soft rays.

Then a century elapses, during which nothing is done towards the natural history of the American Cotti, when in 1836, an English naturalist and traveler, Dr. Richardson, gave to the scientific world the descriptions of two species, his *C. cognatus* and *C. asper*. The latter constitutes now our genus *Cottopsis* after various unsuccessful attempts to refer it to a proper genus. (See Chap. IV.)

In 1837, Mr. Heckel, Professor at Vienna (Austria), made us acquainted with a species which the Museum of Vienna possessed in its galleries, labeled "New York," by calling it *Cottus gracilis*.

In 1840, Prof. S. S. Haldeman had distinguished another species, under the name of *C. viscosus*, inhabiting eastern Pennsylvania.

In 1842, Dr. James E. Dekay described and figured under the name of *Uranidea quiescens*, the *C. gracilis* of Heckel, not knowing that a description of this species had already been published.

¹ BRICKWELL (John). The natural history of North Carolina with an account of the trade, manners and customs of the Christians and Indians, inhabitants. Illustrated with copper plates, whereon are curiously engraved the map of the country, several strange beasts, birds, fishes, snakes, insects, trees, and plants, &c. Dublin, 1737, small 8vo.

In 1845, Mr. W. O. Ayres wrote a somewhat extensive Memoir¹ with a view of demonstrating the identity between *C. cognatus* of Richardson, *C. viscosus* of Halderman, and *Uranidea quiescens* of Dekay. The individuals under examination, taken as a standard, were all secured in the State of Connecticut, and are indeed identical with the species described by Dr. Dekay. *C. viscosus* and *C. cognatus* on the contrary, are two other perfectly distinct species.

After having referred to one and a single species, all the American Cotti, Mr. Ayres proceeds to establish the identity of this one and unique species, with the European *C. gobio*. But we would ask, why should it be identical with *C. gobio*, rather than with any one of the others found in Europe or Asia? Mr. Heckel's investigations being not known in this country in 1845, Mr. Ayres was still under the impression that *C. gobio* was the only species of the genus in the old world; whence the idea of identifying with it those of North America.

Without recapitulating here what we have said in the introduction, respecting the European Cotti, we may recall to mind that the *C. gobio* is not yet determined with accuracy, and that under such circumstances the comparisons lose somewhat of their value. Some have taken for terms of comparison the *C. gobio* of England; others, that of the Seine; still others, that of the Rhine, of the Danube, &c. &c., and now, if these are, as we believe, types of several species, which can we call at present *C. gobio*? Had Mr. Ayres been aware of this state of things, he would have himself admitted, that it was more than premature to bring under this appellation, the American Cotti.

It is evident that after *C. viscosus* and *C. cognatus* are identified with *C. gracilis* it is no longer possible to discern between *specific characters*; the idea of the genus alone is left to the mind. After this is done, you may read Artedi's description, and nothing will be more natural than to find it agreeing perfectly with all existing Cotti. There is a generic identity and not a specific one.

Thus, we shall consider *C. cognatus* and *C. viscosus* as two distinct species, as they were previous to 1845. We erase the name of *Cottus gobio* from the catalogue of fishes of the United States, into which it was too hastily introduced, recalling here to mind that wherever a complete study of the species of fish reputed identical in both continents within the limits of the Temperate Zone has been made, the results have been that species differ from one continent to the other. Yet we would not allow any one to conclude them distinct *à priori*, on this ground. We cannot, on the contrary, too much insist upon the necessity of direct observations and immediate comparisons.

In 1850, appeared the descriptions of two new species brought from Lake Superior, by Prof. Agassiz.

Our own researches have made us acquainted with eight others, besides a ninth; which constitutes a new genus; so that the whole number of the Cottoid group included in the present work amounts to fifteen.

There are a few more species which will be made known to science in the Ichthy-

¹ Boston Journal of Natural History, v., p. 116.

ology of the United States Exploring Expedition. There will also appear the figure of our Cottopsis, the greatest iconographic desideratum of this Monograph.

§ 3. SPECIES WITH FOUR SOFT RAYS TO THE VENTRALS.

I. COTTUS RICHARDSONII, AGASS.

PLATE I. Figs. 1 and 2.

Syn. *Cottus Richardsonii*, AGASS. Lake Sup., 1850, p. 300.—GIRARD, Proc. Am. Ass. Adv. Sc., 1850, p. 410; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

The largest specimens of *Cottus* which we have seen, belong to this species; they are four inches and three-quarters in total length, the caudal fin included.

The general form of the body is elongated, quite regular. Its greatest depth taken behind the pectorals is contained nearly six times in the length; and its least depth, in advance of the caudal, a little more than seventeen times. The decrease is uniform and gradual from the head backwards. The thickness is a little less than the depth. The free space between the second dorsal and the caudal is equal to two-thirds of the depth on the peduncle of the tail.

The head is very much depressed, subconcave above, and forming about the third of the length of the fish, the caudal fin excluded. Its width is equal to the three-fourths of its length, whilst its depth is a little more than the half of the latter. The mouth is large and wide, its amplitude measuring three-quarters of an inch; its angles reach a vertical which would pass through the pupil. The jaws are of equal length, beset with a band of very minute teeth, the summit of which is curved inwards. The lips which line the jaws are capable of great extension, from the branch of the dentary and premaxillaries unto the angles of the mouth; whilst on the symphysis of these bones they are reduced to a mere cutaneous ridge. The eyes are of medium size, circular, and nearer to the end of the snout than to the posterior edge of the opercular by one of their diameters, which is contained five times and a half in the length of the head. The interorbital space above is equal to one of the said diameter, the distance being measured from the visual rims; for the bony arcade is much narrower, as seen in Fig. 18, Plate III., which represents an upper view of the skull of this species. The anterior nostrils, situated nearly midway between the anterior rim of the eyes and the end of the snout, opens exteriorly through a membranous tube which rises above the surface of the skin. The posterior one is nearer to the eye, and situated on a line below the anterior one. The preopercular spine is very stout at its base, very acute at its extremity, and suddenly curved upwards. The subopercular spine is quite conspicuous, although generally concealed under the skin. The posterior and upper extremity of the opercular terminates in a flat and sharp process concealed within the thickness of the membrane which lines the edge of that bone, whence it passes also along the inferior edge of the subopercular. The branchiostegals, six on each side, are slender and cylindrical. The isthmus, under the throat, is three-eighths of an inch wide.

The fins in general are well developed. The first dorsal is composed of eight rays inserted on a basis of six-eighths of an inch; its anterior edge is at a distance of an inch and a half from the extremity of the snout. Its upper edge is sub-convex; the fourth, fifth, and sixth rays being the highest. The second dorsal, twice as extended as the first and one-third more elevated than the latter, is composed of eighteen rays, the highest being situated in the middle of the fin and slightly dichotomized at their extremities. The membrane of the first dorsal reaches the first ray of the second, so that these two fins may be said to be continuous, although a very deep notch still exists between them. The caudal fin, six-eighths of an inch in length, is truncated posteriorly; its upper and lower edge are slightly convex. It contains thirteen full-developed rays with some rudimentary ones; the four middle ones, bifurcated from their very base, dichotomize again on the last fourth of their length, together with the two adjoining rays, on either side. The anal fin commences under the third ray of the second dorsal and terminates a little before the last, although the posterior extremity of the rays of the first extends a little more backwards. In shape, it differs from the second dorsal in being more convex, in having a lower membrane, and, consequently, the tips of the rays extending free beyond it to a greater length. There are fourteen undivided rays. The ventral fins are composed of five rays, a spiny one situated at the outer edge and closely connected to the second (the first soft one) but much shorter. The remaining four are soft and articulated but undivided, the two middle ones being the longest, as shown by the enlarged figure of the left fin beneath Fig. 1. The pectorals are comparatively moderate in size. The rays are fifteen in number, and all undivided. The longest occupy the upper third of that fin and are more slender. Their length is only six-eighths of an inch, consequently much below the length of the head. The base of insertion, seen exteriorly, is crescent shaped. The formula of the fins is as follows:—

Br. 6. D VIII.—18. A 14. C 3. I 5. 6. I. V I. 4. P 15.

The vent being exactly situated on the middle of the total length, the caudal fin included, is consequently nearer the base of insertion of the caudal than the extremity of the snout. It is bordered posteriorly by a small, lanceolated, tongue-like membrane which lies against the anterior ray of the anal.

The lateral line is very conspicuous; it bends itself slightly down on the abdomen to follow afterwards a straight course to the fifth ray of the second dorsal, where the cartilaginous subcutaneous plates cease and minute pores alone exist to continue it inconspicuously to the base of the caudal fin.

The color, so far as we can judge from dead specimens, is of a dark olivaceous brown on the back and sides, blackish on the head, cheeks, and lower jaw. The lower part of the sides is lighter; the belly and lower part of the head reflect rather a yellowish hue with scattered small black spots. The general color of the fins is the same as the region to which they belong; they are maculated and dotted with black or brown. In the young, the spots are spread all over the body, which give to it a marbled or maculated appearance.

The characters by which this species is distinguished from *C. cognatus*, as far, at

least, as those of the latter can be deduced from the description of Sir John Richardson, are as follow: 1st. A more backwards position of the vent. 2d. The lateral line which does not reach the caudal fin. 3d. The more advanced position of the anal relatively to the second dorsal; and, 4th, the shorter pectorals compared to the head.

This species inhabits the northern shore of Lake Superior, where specimens have been collected by Dr. C. T. Jackson and Professor Agassiz, and are now preserved at Cambridge (Mass.). A small individual of the same species may also be seen at the Smithsonian Institution.

II. *COTTUS COGNATUS*, RICH.

Syn. *Cottus cognatus*, RICH. Faun. Bor. Amer. III. 1836, p. 40.—HECK. Ann. Wien. Mus. II. 1837, p. 149.—GIRARD, Proc. Amer. Assoc. Adv. Sc. II. 1850, p. 410; and, Proc. Bost. Soc. Nat. Hist. III. 1850, p. 189.

This species we only know by the description of Sir John Richardson. This author compares it carefully with *C. gobio* of England, which we are told it resembles in numerous points. But this comparison will be valuable only after the *C. gobio* of all regions shall have been submitted to a severe criticism, and after we shall be satisfied of the identity or the difference of specimens collected in all the countries in Europe where that fish has been noticed. We have already mentioned the important fact observed by Mr. Heckel, that the *C. gobio* from Scandinavia belongs to a distinct species.

The *C. cognatus* appears to have nearly the same dimensions as the *C. gobio* of England; the shape and size of the head are similar, but the mouth is larger. The head forms one-third of the length, the caudal fin excluded; its width is equal to its length; its height is two-thirds of its breadth. The jaws are of equal length. The premaxillaries, the dentaries, and the vomer, are armed with short, velvet-like teeth. The tongue is smooth, broad, and short. The spine on the preopercular is small, curved upwards, and hidden under the skin. The branchiostegal rays are slender and cylindrical, as in *C. Richardsonii*, whilst they are stout and flattened in the *C. gobio* of England. The isthmus measures half an inch.

The greatest depth of the body, taken at the origin of the first dorsal, corresponds nearly to the transverse diameter of the same region, whilst towards the insertion of the caudal, the thickness of the body is reduced to the half of its depth. The posterior part of the body is rather acute than rounded. The vent is a little nearer the end of the snout than the insertion of the caudal. The lateral line runs parallel with the back, to which it is nearer than to the belly.

The origin of the first dorsal takes place a little behind that of the ventrals, at the same distance from the end of the snout as in *C. gobio* of England; but it extends more backwards, having two rays more,¹ the largest of which measure

¹ Cuvier gives from six to nine rays to the first dorsal of *C. gobio*; Sir John Richardson informs us that, as far as his observations go, he constantly found six spiny rays to the first dorsal, and sixteen articulated,

one-third of the depth of the body. The second dorsal, twice as long as the first, is separated from the latter by a space less than a line. It contains eighteen articulated and simple rays, with the exception of two central ones which are very slightly forked. The anal is composed of fourteen articulated, but simple, rays; its origin is opposite to the sixth ray of the second dorsal and terminates, as usual, before the latter. The caudal, one-sixth of the total length, unites with the tail in a straight line; its rays, fifteen in number, are more or less subdivided or else dichotomized. The ventrals, arising a little behind the pectorals, contain five rays, of which four are soft and articulated, and one spiny, slender, and half the length of the others, close to the anterior or outer edge of the fin, and concealed by the skin. The pectorals are large and fan shaped; the rays of which they are composed are all articulated but not branched, the longest equalling the head in length.

Br. 6. D VIII. — 18. A 14. C 15. V I. 4. P 15.

“The under surface is silvery-gray minutely spotted with dark brown: on the sides, the dots are intermingled with crowded, irregular blotches of the same color, and on the back and top of the head the color is dark brown, nearly uniform, few spots of the light color appearing.”—(RICH.)

Sir John Richardson gives four inches as the total length of this species; we regret not having had the opportunity of studying it in nature; but there exist no specimens to our knowledge in any public or private collection of fishes in the United States. We regret likewise that the author of the *Fauna Boreali-Americana* has not had it figured; the more so that it resembles so much its congener of both continents.

III. *COTTUS WILSONII*, GIRARD.

PLATE I. Figs. 3 and 4.

In visiting the collection of fishes at the Academy of Natural Sciences of Philadelphia, in November 1850, we saw a *Cottus* labelled “Pittsburgh (Pa.),” presented by Mr. Jacob Green. After a careful examination of the unique specimen preserved in that cabinet, we satisfied ourselves that it belonged to a species distinct from any one hitherto known, and took pleasure in dedicating it to Dr. Thomas B. Wilson. Indeed, before that time, we had seen immature specimens of the same species, but we were unable to characterize it until we met with the one just mentioned.

The size of the individual figured and described is four inches and a quarter. The head forms exactly the fourth of that length. With regard to the general form it is amongst all the species the one whose depth diminishes least rapidly backwards. The greatest depth is comprised nearly six times in the length, and the least depth, on the peduncle of the tail, only twelve times. The thickness is a

but simple, to the second, whilst Cuvier found in the latter seventeen to eighteen rays, the last of which is branched, and some of the middle ones forked. These facts must be taken into consideration in making a critical revision of the European *Cotti*.

little less than the depth. The head is much flattened above, gradually sloping towards the end of the snout. Its width is equal to the space comprised between the end of the snout and the base of the preopercular spine. The mouth is very broad; its angles, however, do not extend beyond the pupil. The palatine asperities are more conspicuous than in any of the other species which exhibit traces of them. They occupy an oblong and elongated area on the surface of their bones. The eyes are proportionally small; their diameter is contained nearly six times in the length of the head. The interorbito-frontal space measures a quarter of an inch, and accordingly, is broader than in any other species. The anterior and posterior nostrils are both tubular. The posterior one, the largest, is situated above in advance of the orbit; the anterior one is nearer the orbit than the end of the snout. The preopercular spine, directed obliquely upwards, is short, stout at its base and very acute at the tip. Underneath, and directed downwards, there exists a second very minute, blunt spine. The isthmus is five-sixteenths of an inch wide.

The surface of the head exhibits numerous holes all along the tracks of the cephalic channels of the lateral line, by means of which a direct communication is established with the surrounding medium. Several of these holes exist on the snout in the vicinity of the nostrils. They appear more distinct on the specimen figured, on account of the decomposed state of the epidermis which is deprived of all its pigmentum.

The origin of the first dorsal is one inch and a quarter from the extremity of the snout. Its rays, seven in number, occupy a longitudinal space of five-eighths of an inch, the last ray sending its membrane to the very base of the first ray of the second dorsal. The latter is composed of sixteen rays, the central ones exhibiting a slight bifurcation on their summit, without, however, solution of continuity. It extends on a basis of one inch and a quarter, that is, exactly twice the length of the first dorsal. Its anterior edge is nearly of the same height with the middle, and its decrease takes place gradually towards the posterior edge, distant from the caudal three-sixteenths of an inch. The origin of the anal fin is opposite the third ray of the second dorsal. It contains thirteen unbranched rays. The exterior margin of this fin is convex, the middle rays being a little longer than those of the second dorsal. The central rays of the caudal are twice subdivided; the posterior margin of this fin is subtruncated; differing in this respect from that of *C. Bairdii*. The insertion of the ventral fins takes place, as usual, under the pectorals; but in this species it is considerably more in advance of the first dorsal fin, whilst in *C. Bairdii*, it is situated immediately under the first ray of the anterior dorsal. They are composed of four soft, jointed, but unbranched rays, the second and third being the longest. The spiny ray is very slender. When bent backwards, the tip of these fins is far from reaching the vent, thus proportionally shorter than those of *C. Bairdii*. Their more advanced position is not sufficient to account for the difference. The pectorals are broad, with a crescentic base of insertion; they are composed of fourteen rays, the four uppermost but two, are bifurcated, a character quite peculiar to this species amongst the American ones.

Their tip will reach backwards, the origin of the second dorsal only, thus proportionally shorter than those of *C. Bairdii*.

Br. 6. D VII.—16. A 13. C 2. I. 4. 4. I. 2. V I. 4. P 14.

The vent is situated under the second ray of the second dorsal.

The lateral line is nearly straight, and can be traced to the base of the caudal. The cartilaginous capsules, however, disappear under the fourteenth ray of the second dorsal, whilst the fall takes place under the last ray. Its peculiar appearance in the specimen figured, is owing, as already observed, to the decomposed state of the epidermis, rendering the holes of the dermic layer more conspicuous.

The accompanying figure is the only one which was not drawn by Mr. Sonrel, from nature. Our sketch was made originally with a mere view of giving the striking character of the bifurcation of the pectoral fins.

Specimens of this species, the largest measuring only three inches and five-eighths, were sent to the Smithsonian Institution, by Prof. L. D. Williams of Meadville, and collected by that gentleman in French Creek (Pa.).

The ground color of these is yellowish-green, intermingled with cloudy patches of brownish-black. The base of the caudal is black. All the fins, the ventrals excepted, are banded with black. The latter have the uniform palish-yellow of the belly.

Prof. Baird's specimens were collected by himself in a tributary of the Alleghany River, at Foxburg (Pa.).

IV. *COTTUS BAIRDII*, GIRARD.

PLATE I. Figs. 5 and 6.

Syn. *Cottus Bairdii*, GIRARD, Proc. Amer. Assoc. Adv. Sc. II. 1850, p. 410; and, Proc. Bost. Soc. Nat. Hist. III. 1850, p. 189.

Cottus gobio, KIRTL. Bost. Journ. Nat. Hist. V. 1847, p. 342.

This, amongst all the species represented on our plates, is the one which has the most elegant shape. The uniform declivity of the snout, passing gradually over the eyes, and backwards to the tail, without the slightest deviation from a slightly concave or almost straight course, contributes to that elegance, rendered more perfect by a similar outline of the belly. Now, as the body tapers very gradually away towards the tail, together with the thickness, the general form is still improved by these proportions of height and breadth. So we might call the general form, elongated, although at first sight it will strike us as being rather short, especially when compared to *C. viscosus*.

The greatest depth of the body, taken at the origin of the first dorsal and ventral fins, enters only six times and a half in the total length, and the least depth, in advance of the caudal, is contained in it nearly fourteen times and a half. The greatest thickness is equal to the depth; but it diminishes more rapidly backwards, so that, on the peduncle of the tail, the thickness is reduced to one-half of the depth.

The head forms the third of the length of the fish, the caudal fin excluded; it is one-third longer than broad, and less obtuse on the snout than in *C. viscosus*.

The mouth is proportionally great; its angles reach posteriorly a vertical which would pass in advance of the pupil. The jaws and teeth, as far as external investigations go, do not exhibit any peculiarity which is not to be found in other species. On the other hand, the palatine bones are in some cases provided with minute asperities or rudimentary teeth. The eyes are subcircular in form, proportionally large, and their longitudinal diameter contained only four times in the length of the head. The anterior nostrils are nearer the end of the snout than the orbit. The posterior ones are above and nearer the orbit, resembling a similar opening below and corresponding to the anterior extremity of the anterior sub-orbital. The preopercular spine is quite small, very acute, and bent obliquely upwards, assuming, on the figured specimen, a hook-like appearance. The spine on the subopercular is more conspicuous than in *C. viscosus*. The gill openings are also greater, and the isthmus smaller, than in the latter.

The first dorsal is very low; its origin is exactly opposite to the base of the ventrals, and distant from the end of the snout by fifteen-sixteenths of an inch. Its upper edge is almost straight, and parallel to the back, the rays having nearly all the same height. The latter are six in number, occupying a space of three-eighths of an inch, the last ray sending its membrane to the second dorsal.

The origin of the second dorsal is in advance of the vent, extending backwards till quite near the caudal, being two times and a half as long as the first dorsal. It contains sixteen unbranched rays, the last of which is often double. The anterior edge of the anal corresponds to the space between the fifth and sixth rays of the second dorsal, and terminates before the latter. The tip of its rays, however, extend nearly as far back. The rays, thirteen in number, are as long as those of the second dorsal, but, their membrane being shorter, the anal appears not quite as high. The caudal is elongated, posteriorly rounded off, and quite convex; its length is contained four times in that of the body and head inclusive, thus constituting the fifth part of the total length. The middle rays show a double bifurcation. The insertion of the ventrals takes place back of that of the pectorals, and, when bent backwards, their tip nearly reaches the vent. There are four soft, articulated, but unbranched rays, of which the two middle ones are the longest.

The pectorals are proportionally longer than in *C. viscosus*; the rays are slender, all undivided, and their tip reaches the origin of the anal, and, consequently, the fifth of the second dorsal. The base of insertion of these fins, seen exteriorly, is almost vertical. The formula of the fins is nearly identical with that of *C. Wilsonii*.

Br. 6. D VI.—16. A 13. C 2. I. 4. 4. I. 3. V I. 4. P 14.

The anus is nearer the snout than the extremity of the caudal fin, and under the first ray of the second dorsal.

The lateral line is conspicuous from head to tail. It takes a straight course until the fourteenth ray of the second dorsal, where it sinks gradually down to reach the medial line of the peduncle of the tail, just at the termination of the second dorsal, whence it takes again a straight course to the base of the caudal fin.

The general ground of the color is grayish, maculated, and dotted with black.

The top of the head and back are very dark, the sides and belly lighter, yellowish without the large spots. The dorsals, pectorals, and caudal fin are banded; the ventrals and anal, unicolor and only dotted.

This species may be readily distinguished from *C. Richardsonii* by the shape of the first dorsal, the length of the pectorals, their vertical base of insertion, and the convexity of the posterior margin of the caudal.

Caught by Prof. Baird in the Mahoning River at Poland (Ohio). Specimens are preserved at the Smithsonian Institution and in Prof. Agassiz's cabinet.

V. *COTTUS ALVORDII*, GIRARD.

PLATE I. Figs. 7 and 8.

We have before us the smallest species hitherto described of the genus, measuring not quite two inches and a half. Whether it does not attain a larger size, we are not prepared to decide, as the specimen figured is the only one which we have hitherto seen. But that it belongs to a distinct species is readily apparent. The general form of the body resembles that of *C. meridionalis*, tapering suddenly away towards the tail, but the fins differ widely. The head forms a little more than the fourth of the entire length. The greatest depth of the body is contained about five times in the length, whilst the least depth enters in it nearly thirteen times. It is deeper than thick. The anterior region of the body is arched. The neck is depressed and the snout short and obtuse. The mouth is small; its angle extending not quite as far back as the pupil. The preopercular spine is short and stout, very much curved upwards, and slightly inwards. Below the convexity of the preopercular, there exists another very minute spine, the point of which is directed obliquely downwards. The gill openings are separated below by an isthmus of two-twelfths of an inch. The eyes are proportionally large, subcircular; their longitudinal diameter is contained four times in the length of the head. The anterior nostrils are nearer the orbit than the end of the snout.

The origin of the first dorsal is situated six-eighths of an inch from the extremity of the snout. It is composed of seven rays extending on a longitudinal basis of five-sixteenths of an inch. Its upper margin is regularly convex; the third and fourth rays are the longest; the first and second have the size of the fifth and sixth; the seventh is the shortest. The membrane runs from its tip to the anterior margin of the second dorsal, meeting the first ray on the middle of its height. How different this fin is from the similar one in *C. meridionalis*, an inspection of both figures will show at once.

The second dorsal is very close to the first, composed of sixteen undivided rays, the last of which is double. Its upper margin is likewise convex. The origin of the anal is under the third ray of the second dorsal; its outer margin is much more convex than that of the latter, and contains thirteen rays, the last one double. The caudal fin is rounded posteriorly. It is contained six times in the entire length. There are ten fully developed rays, eight of them bifurcated to a considerable length. The ventrals are very short and broad, inserted immediately under the middle of the pectorals, in advance of the first dorsal. The pectorals

are broad and proportionally much developed, for their tip reaches backwards, the fourth ray of the second dorsal, and the first ray of the anal fin. The base of insertion of these fins is crescent-shaped and close to the gill opening. In this respect *C. Alvordii* differs considerably from *C. meridionalis*. The rays are fifteen in number, all undivided, the eight lowermost alone overrunning the membrane of the fin.

Br. 16. D VII. — 16. A 13. C 3. I. 4. 4. I. 2. V I. 4. P 15.

The lateral line, nearly straight, vanishes already under the seventh ray of the second dorsal, whence the series of minute pores cannot be followed to the tail without an eye-glass, when it is seen along the back as far as the posterior ray of the second dorsal, and there disappears entirely.

The anal opening is a little nearer the extremity of the jaws than the base of the caudal fin. It is provided posteriorly with a tongue-shaped membrane, broad at its origin, and very acute on its extremity, so that when seen in a profile view, it has the appearance of an ordinary ray. Our figure, however, gives a clear idea of it, as a solution of continuity exists between it and the first ray of the anal. A close examination will likewise show a structural difference.

The head and back are yellowish-brown, clouded on the sides. The belly and fins are yellowish; the first dorsal alone having two black spots on its posterior half.

This species inhabits the streams emptying into Lake Huron, in the vicinity of Fort Gratiot, where it was collected in 1850, by Major B. Alvord, and presented by this officer to the Smithsonian Institution, where the original specimen is preserved.

VI. *COTTUS MERIDIONALIS*, GIRARD.

PLATE I. Figs. 9 and 10.

Syn. *Cottus meridionalis*, GIRARD, Proc. Amer. Assoc. Adv. Sc. II., 1850, p. 410; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

Nothing is more dissimilar than the general outline of this species and that of *C. Bairdii*, and yet the absolute length of both species is exactly the same on the specimens figured. Indeed, the species which *C. meridionalis* resembles most in shape, is *C. Alvordii*, and still there are differences which could not for a moment be overlooked; besides the fact of their remote habitat, which would likewise cause doubts as to their identical relationship. It is not without a certain resemblance with *C. viscosus*, and did it not belong to a different division of the genus by a hidden character, its stout and contracted body would scarcely suffice to distinguish it from the latter.

The greatest depth is contained but five times in the total length; four times only when we exclude the caudal fin, the length of which is equal to the depth. The body tapers very rapidly away; its least depth, on the peduncle of the tail, enters fifteen times in the total length. The greatest thickness is considerably less

than the depth. The peduncle of the tail appears more elongated than in any other species.

The head forms nearly the fourth of the total length; it being contained a little more than twice in the length of the body, the caudal fin excluded. Its width is equal to the length of its upper surface. The eyes are a little smaller than in *C. Bairdii*, their form is circular, and their diameter enters five times in the length of the head. The interorbito-frontal space is equal to one diameter. The anterior nostril is situated nearly on the middle of the space between the end of the snout and anterior rim of the eye. The posterior one is above, close to the orbit. The mouth is larger than in *C. Bairdii*, and the palatine bones are likewise provided with teeth-like asperities, forming a more elongated patch.

The preopercular spine is very conspicuous, stout, directed obliquely upwards and backwards. Under it we observe a second preopercular spine, much smaller, of the size of that of the subopercular, the point of which is directed vertically downwards, and below, a third, still smaller, directed obliquely forwards. The gill openings are smaller, and consequently the isthmus is larger than in *C. Bairdii*.

The first dorsal commences a little behind the insertion of the ventrals and is a little more distant from the end of the snout than in *C. Bairdii*. Its shape is very different from that of the latter species; its upper edge is very convex. There are seven rays, the second and third the highest, the first is equal to the fourth, the fifth, sixth, and seventh are gradually diminishing. The second dorsal, contiguous to the first, commences in advance of the vent, and is composed of seventeen undivided rays, the last of which is branched. The upper edge of this fin is also more convex than in any other species. The origin of the anal corresponds to the space between the fourth and fifth rays of the second dorsal. Its last ray is double. The caudal fin is shorter than the head; it is convex posteriorly as in *C. Bairdii*. The seven middle rays are bifurcated only once.

The insertion of the ventrals takes place immediately under the pectorals; amongst the four soft rays the two middle ones are the longest and equal in length. The two outer ones are likewise equal in size. The pectorals are shorter and broader than in *C. Bairdii*; they scarcely reach the fourth ray of the second dorsal, but leave the anal behind. Their base of insertion is oblique but nearly straight. The tip of all the rays extend beyond their membrane.

Br. 6. D VII.—17. A 12. C 4. I. 4. 3. I. 4. V I. 4. P 14.

The vent is nearer the snout than the tip of the caudal.

The lateral line runs parallel to the back; it is conspicuous until the thirteenth ray of the second dorsal, where it vanishes into a series of pores so minute as not to be distinguished without the aid of a lens.

We cannot give anything positive on the color of this species, the specimens collected by Prof. Baird having lost their general hue. The body, however, shows still some faint blotches of darker appearance than the ground color; and the fins appear to have been banded.

This species inhabits the tributaries of James River (Va.). Specimens are preserved in the Museum of the Smithsonian Institution.

§ 4. SPECIES WITH THREE SOFT RAYS TO THE VENTRALS.

VII. *COTTUS GRACILIS*, HECK.

PLATE I. Figs. 11 and 12.

Syn. *Cottus gracilis*, HECK. Ann. d. Wien. Mus. II., 1837, p. 148.—GIRARD, Proc. Amer. Ass. Adv. Sc. II., 1850, p. 411; and, Proc. Bost. Soc. Nat. Hist., III., 1850, p. 189.
Uranidea quiescens, DEKAY, New York Fauna, 1842, p. 61, Pl. V. Fig. 14.
Cottus gobio, AYRES, Bost. Journ. Nat. Hist., V., 1845, p. 121, Pl. XI.

The history of this species is quite interesting: described abroad for the first time as the second species of *Cottus*, peculiar to this country, its description remained unknown for years on this side of the Atlantic, and when Dr. Dekay published the Fauna of the State of New York, he even lost sight of the fresh-water Cotti, and proposed for it a new genus. Next we find Mr. Ayres restoring this species to its true genus, and yet misled on the question of the species, an error which he would not have committed if the paper of Mr. Heckel had been at his command.

This is one of the small species of the genus, scarcely exceeding three inches in length. The specimens which we have had under examination had not quite that size. The general appearance is fusiform, slender, less so, however, than *C. boleooides*; but on the other hand, it is shorter than the latter, resembling more in shape *C. Bairdii*. The greatest depth of the body is contained a little more than six times in the total length; a little less thick than deep anteriorly, it diminishes gradually towards the tail, though more rapidly in thickness than in depth. The latter, on the peduncle of the tail is reduced to the proportions of one-thirteenth of the total length.

The head forms about the fourth of the total length. The occipital region is slightly sloping backwards, thus giving to the neck a depressed appearance. From the orbits to the end of the snout, the head is rather rounded, although not abruptly truncated. The eyes, circular in form, are one-sixteenth of an inch in diameter, which is comprised nearly four times in the length of the head. Their frontal distance is only the half of their diameter. The anterior nostrils are situated midway between the orbits and the snout; the posterior ones are higher up, and close to the eyes. The mouth is proportionally great; its angles nearly reach the pupil. The lips are well developed, but the teeth are not very conspicuous. Palatine teeth have been assigned to this species, but are not to be found in the specimen figured. There is nothing which resembles teeth on the tongue as ascribed to *Uranidea quiescens*. The preopercular spine is but little prominent; that of the subopercular is constantly concealed under the skin. The gill openings are oblique; the isthmus is a quarter of an inch wide. There are constantly six branchiostegal rays, even in the specimens in which Dr. Dekay signalizes seven.

The origin of the first dorsal is six-eighths of an inch distant from the extremity of the snout; it is not quite half an inch long, and its height is less than the half of its length. Its upper edge is rounded and convex; the first and second rays being a little shorter than the third and fourth; there are eight rays in all; the

longest of which are one-third the depth of the body. The second dorsal is contiguous to the first, which sends to it the membrane of its last ray. Commencing above the vent, it is more than twice as long, and at least twice as high as the first, and composed of sixteen undivided rays, the middle ones being the longest and as high as the body itself on the region to which they correspond. The origin of the anal is under the third ray of the second dorsal, and terminates under the thirteenth. It has most generally twelve, sometimes eleven rays, which equal in height, if they do not surpass, the corresponding rays of the second dorsal. The caudal is sub-truncated; its length enters five times and a half in the total length of the fish. It is composed of sixteen rays, of which the five middle ones are subdivided twice; the two next on each side subdivide only once; finally, the others, four to the upper lobe, and three to the lower one, remain undivided, and are simply articulated. The ventrals are situated exactly under the pectorals, and when bent backwards, they reach the vent, and even sometimes go beyond it. They are composed of a short spiny ray, and three soft articulated and unbranched ones, of which the first is the shortest, and the middle one the longest. The insertion of the pectorals is oblique, or rather crescent-shaped, and takes place immediately behind the gill opening. Their tip reaches the third or fourth ray of the second dorsal. They are composed each of thirteen soft and undivided rays, of which the seven lowermost are a little thicker, and extend beyond the membrane which unites them.

Br. 6. D VIII.—16. A 12. C 3. I. 5. 4. I. 2. V I. 3. P 13.

The lateral line, slightly bent downwards on the abdominal region, re-ascends gradually nearer the back, and vanishes on the last third of the length of the second dorsal, that is, under the eleventh ray, sometimes even already on the middle of that fin, whence it follows its course towards the tail by means of minute pores after having made a sudden fall near the termination of the second dorsal in order to reach the centre of the peduncle of the tail, and then run directly to the base of the caudal fin.

The color, according to Mr. Ayres, seems to vary within considerable limits: "The prevailing color of the sides is light yellowish-brown, with numerous blotches of darker brown, sometimes, but not always, amounting to irregular bands, which occasionally cover the greater part of the side. The head is in general darker than the body. The under side of the body, from the lower jaw to the caudal fin, is yellowish-white. The first dorsal fin is of a light brown, with dark spots, and occasionally with bands; the upper margin of the fin is red. The second dorsal, pectorals, and caudal, are colored like the first dorsal, except that they are destitute of the red margin. The ventrals are nearly transparent. The anal is like the second dorsal, but not quite so dark," (pp. 123 and 124.)

This species is found in the States of Massachusetts, Connecticut, and New York. Dr. Dekay found it in Lake Pleasant, and previously, Dr. Emmons had it from Round Lake (N. Y.). Mr. Ayres caught his at Manchester (Ct.). Prof. Baird procured several of them from the northern tributaries of the Hudson, in Schroon township, Essex county (N. Y.), near Root's tavern.

Preserved specimens exist in the cabinet of the Boston Society of Natural History; in the State Museum, at Albany; and at the Smithsonian Institution.

VIII. COTTUS VISCOSUS, HALD.

PLATE II. Figs. 1 and 2.

Syn. *Cottus viscosus*, HALD. Suppl. to a Monogr. of Limn., &c., 1840, p. 3.—GIRARD, Proc. Amer. Assoc. Adv. Sc. II., 1850, p. 411; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

In 1840, this species was announced to the scientific world rather than described. The author having no means of establishing direct comparisons, could not draw an accurate distinctive diagnosis. He knew not Mr. Heckel's *C. gracilis*, and had only before him an incomplete description of *C. gobio*, from Europe.

The specimen figured, is not quite four inches long. Since the latter has been drawn, we have seen another, measuring nearly four inches and a half.

The general form is sub-cylindrical, of rather stout appearance. The width, near the head, is greater than the depth, and sometimes both of these dimensions are equal. The greatest depth under the first dorsal, is comprised five times and a half in the entire length, and the least depth a little more than fifteen times. The head forms the two-ninths of the length of the fish. The occipital region is depressed, but flat; the nose convex, and the snout obtuse. The mouth is very little cleft, and its angles do not extend farther back than the anterior rim of the eye. The lips are very fleshy. The eyes themselves are of medium size, and circular in form; their diameter is contained five times in the length of the head. The tubular nostrils are nearer the eyes than the extremity of the jaws. The preopercular spine is stout and prominent, acute, directed obliquely upwards. In some cases there exists a second, very small, slender, acute spine, immediately under the base of the first, having its point directed vertically downwards. That on the inferior angle of the subopercular is very conspicuous, acute, directed as usual downwards and forwards. The gill openings are separated, below, by an isthmus of three-eighths of an inch.

The anterior margin of the first dorsal is distant one inch and a quarter from the extremity of the snout. It is rather low, uniformly arched, and composed of eight rays, the third, fourth, and fifth, nearly equal, and longest. The membrane between that fin and the second dorsal is quite low. The second dorsal is convex like the first, containing seventeen undivided rays on a base of one and an eighth of an inch, twice and a half as long as the base of the anterior fin. The origin of the anal is under the fourth ray of the second dorsal and is more convex than the latter. It is composed of twelve undivided rays, the last, as in many instances, double, opposite to the fourteenth of the second dorsal. The longest rays of both second dorsal and anal, are of equal length, but the membrane of the latter fin is more deeply notched, so as to make it appear shorter. The caudal is rounded posteriorly, and forms two-elevenths of the entire length. It is composed of eleven well developed rays, with four short ones above and three below. The nine middle ones are bifurcated on the last two-thirds of their length, and each branch again subdivided near the tip without solution of continuity; this latter

feature not being exhibited in the figure. The insertion of the ventrals takes place in advance of the anterior dorsal, and behind the base of the pectorals. The two inner rays are the longest, as seen in the enlarged figure of these fins beneath Fig. 1. They do not reach the anus when bent backwards. The pectorals are of medium size, shorter than the head, composed of twelve unbranched rays. The membrane is deeply notched on the outer edge of the seven lowermost rays. Their base of insertion is nearly straight. When bent backwards they scarcely reach the anterior margin of the second dorsal, and leave the anal behind.

Br. 6. D VIII.—17. A 12. C 4. I. 5. 4. I. 3. V I. 3. P 12.

The lateral line is slightly inflexed on the abdomen, but runs straight along the back until the posterior extremity of the second dorsal, when the fin takes place obliquely towards the centre of the peduncle of the tail, and straight again to the base of the caudal. The series of pores commences under the tenth ray of the second dorsal.

The anus is situated a little nearer the end of the snout than the extremity of the caudal fin, consequently nearer the base of that fin than the snout.

The color is thus described by Prof. Haldeman: "yellowish, clouded with black, the first dorsal fin edged with a narrow line of orange."

The following information respecting the habits of this species, is from the notes of Professor Baird:—

These fish usually inhabit clear, spring waters, especially the spring runs which flow through rich meadows, bordered by turf, and having a shallow pebbly bottom. They lie concealed under projecting clods, flat stones, boards, or whatever may serve their purposes of concealment. On being disturbed, they usually hasten off to fresh cover, but sometimes remain motionless. Occasionally they occur in larger bodies of water, of less purity; but we have never seen them in creeks or rivers. Sometimes they are seen lying close to the edge of rivulets formed by leaking embankments, and where the water is far from clear. They always lie close to the bottom, and are never seen poised in the water.

The eggs are laid from the middle of April to the end of May, and are deposited in round packets about the size of an ounce bullet, under boards, stones, and in shallow, springy water. It is possible that they are watched by the parent, as we have frequently found individuals under the same cover as the eggs. The ova are of a rose color, and about the size of No. 3 shot, conveying the impression of disproportionate size. Occasionally, we have found the eggs with embryos moving freely within the envelope. A set examined April 22d, 1848, had the eye very distinct, and of large size. The foetal fin extended from the head, by the tail, to the anus. In the course of the day, many became liberated, and swam about with the yolk bag attached. This was sessile, and filled with a transparent, reddish liquid, excepting opposite to the embryo, where was a hard, yellowish cake. All our attempts at raising the young, or of development of the egg, failed for want of fresh spring water.

The body is the most slimy amongst the known species, whence its name *viscosus*, which we think is well appropriated. Specimens have been collected by Prof

Baird, about Carlisle (Pa.), in Mountain and Yellow Breeches Creeks, and Letart Spring, the largest of which were three and six-eighths of an inch. They all agree with the above description, excepting the color of an individual from Mountain Creek, which we found of a dark and uniform black.

We owe to the kindness of Prof. S. S. Haldeman, an authentical specimen, three inches long, so that there can be no doubts left with regard to the species which is here described.

The specimen figured was caught in the vicinity of Carlisle, and is preserved at the Smithsonian Institution, together with several others of the same vicinities. Specimens were also obtained from the Schuylkill at Reading (Pa.), and from the tributaries of the Potomac, at Rohrerstown (Md.), and in Rock Creek, Washington (D. C.). So that the range of *C. viscosus* is Eastern Pennsylvania and Maryland.

IX. *COTTUS FRANKLINII*, AGASS.

PLATE II. Figs. 5 and 6.

Syn. *Cottus Franklinii*, AGASS. Lake Sup. 1850, p. 303.—GIRARD, Proc. Amer. Assoc. Adv. Sc. II., 1850, p. 411; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

Here is a species which we might easily have identified with the preceding, so much it resembles it by its general appearance, had we not looked into the anatomical as well as zoological peculiarities of both species.

Before we were prepared to formulate distinctively the characters by which this species differs from its congeners, the form of the skull had already satisfied us that it was distinct. In the first place, and to speak only here of this species and of *C. viscosus*, which appear so much alike, the conformation of the skull has something so peculiar that, when once well understood, it will be easy to tell at first sight to which of these two species such and such skulls may belong (Compare Figs. 8 and 12 of Plate III.).

If the differences exhibited in those profiles are not specific, comparative osteology can no longer be a sure guide in the study of species, nor can anatomy be of any help to zoology. But to this conclusion we have not yet arrived; we know what comparative osteology of the skull is worth, and, confident in the future of that science, we should have established the two species as distinct on those characters alone.

Zoologically speaking, the general form is short and stout. The greatest depth is contained five times and a half in the total length, and is proportionally greater than in *C. viscosus*. The least depth is one-nineteenth of the length. The body tapers rapidly away, as in *C. meridionalis* and *C. Alcockii*. The peduncle of the tail is more slender, and the back more arched than in *C. viscosus*. The thickness is greater than the depth for a considerable length; towards the tail, however, the depth becomes greater. The body, as a whole, has rather a cylindrico-conical shape.

The head, proportionally shorter than that of *C. viscosus*, is contained two times and a half in the length of the body, the caudal fin excluded. The snout, also, is

much less obtuse, and the mouth more deeply cleft. The eyes are subcircular; their longitudinal diameter is contained four times in the length of the head. The interorbital-frontal space is equal to the half of that diameter. The anterior nostrils are situated midway between the orbit and the extremity of the jaws; the posterior ones are nearer the orbits.

The preopercular spine is hook-like, very acute, and different in all respects from that of *C. viscosus*. It resembles more that of *C. Bairdii* than any other species. The subopercular spine is slender and very acute.

In spite of the great resemblance between the fins of this species and the preceding one, a careful comparison shows that the paired fins are proportionally shorter. The base of the pectorals is slightly crescent shape; the tip of its rays scarcely reach the anterior edge of the second dorsal fin. The five uppermost rays do not overrun their membrane quite as much as exhibited in the figure. The ventrals are nearer the isthmus than in *C. viscosus*, and when bent backwards, they leave a greater space between their tip and the vent. Their insertion takes place immediately under the base of the pectorals instead of being situated behind.

The first dorsal is nearly of the same height with the second; it is longer than in *C. viscosus*; its upper edge is also more convex. There are eight slender rays, the first and last being of equal size. The second dorsal is contiguous to the first, and terminates at a greater distance from the base of the caudal than in *C. viscosus*. It contains seventeen rays, or only sixteen, the last one, double. The caudal fin is posteriorly truncated, whilst it is rounded in *C. viscosus*. It forms nearly the sixth part of the total length. The origin of the anal is under the fourth ray of the second dorsal, and terminates under the thirteenth. When bent backwards the tips of the rays do not reach as far as those of the second dorsal.

Br. 6. D VIII.—17. A 12. C 1. I. 5. 4. I. 1. V I. 3. P 14.

All the rays are unbranched with the exception of two in the centre of the caudal, which, however, bifurcate only once beyond the middle of their length.

The vent is situated nearer the base of the caudal fin than the tip of the snout.

The lateral line follows the curve of the back; it vanishes already under the sixth ray of the second dorsal, whence the series of minute pores is very little conspicuous. Its fall near the tail takes place less abruptly than in *C. viscosus*.

This species inhabits the southern and eastern shores of Lake Superior, where it has been collected first by Prof. James Hall of Albany, and afterwards by Prof. Agassiz, in whose cabinet specimens are still preserved. It is also to be seen in the collection of fishes at the Smithsonian Institution.

The specimen figured is the largest we have seen. Its total length is three inches and one-sixteenth.

X. COTTUS GOBIOIDES, GIRARD.

PLATE II. Figs. 3 and 4.

Syn. *Cottus gobioides*, GIRARD, Proc. Amer. Assoc. Adv. Sc. II., 1850, p. 411; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

The first impression which strikes the observer after a superficial glance at this species, is a general resemblance with *C. Richardsonii*, from which it differs, however, much more than from several others, by several peculiarities of its structure. What leads to this impression is its large mouth, its large head, and undoubtedly its profile, as well as the general outline of the body. But as these species belong to two different sections, their intimate affinities are found more remote than might be anticipated.

Its large mouth distinguishes it readily from all the species, which possess, like it, three soft rays only to the ventral fins, with the exception, perhaps, of the following species, to which it has much affinity.

The greatest depth of the body is contained five times and a half in the entire length from the snout to the tip of the caudal fin; whilst the least depth enters in it nearly fifteen times. These dimensions, when compared to those in *C. boleooides*, are very striking, when we bear in mind the absolute size of the individuals which we here describe. In *C. boleooides*, three-quarters of an inch shorter than *C. gobioides*, we find both the greatest and least depth comprised a greater number of times in the length. The greatest thickness is a little less than the depth on the anterior region.

The head forms three-eighths of the entire length, proportionally a little shorter than in *C. boleooides*. Besides, it is much broader than deep, and its frontal length is sensibly equal to its width. The flattening of the head above the eyes and the convexity of the neck, make the frontal line appear as if more depressed than in other species. The snout is obtuse, differing greatly in this respect from *C. Richardsonii*. The angles of the mouth reach a vertical, which would pass beyond the pupil. The eyes themselves are circular and proportionally small; and their diameter is contained a little more than four times in the length of the head. The interorbital-frontal space is greater than in *C. boleooides*. The preopercular spine is much developed and stout, suddenly curved upwards. The spine of the subopercular is small and acute. The gill openings are large and oblique, and separated under the throat by an isthmus of four-eighths of an inch.

The first dorsal commences one inch and one-sixteenth from the extremity of the snout, and extends on a basis of half an inch, leaving a considerable space to be filled by the membrane. The origin of the second dorsal is opposite to the vent, and composed of seventeen undivided rays. Its upper edge is more convex than in *C. boleooides*, the first and last rays being sensibly shorter than the middle ones. The commencement of the anal takes place between the third and fourth rays of the second dorsal; it is higher than the latter, and composed of twelve undivided rays. The caudal is rather rounded than truncated posteriorly, and is contained but a little less than six times in the entire length. Its eight middle rays are bifurcated

on their posterior half, and at their tip there seems to be a slight indication of a second bifurcation. The ventrals are inserted immediately under the first ray of the anterior dorsal, and when bent backwards do not reach the anus. The base of the pectorals is oblique, but not crescent-shaped; if directed backwards their tip will reach the third ray of the second dorsal, and leave the anal behind them. Their rays, fourteen in number, are undivided, and the six lower ones, shorter and thicker, extend beyond the membrane of that fin.

Br. 6. D VII.—17. A 12. C 3. I. 4. 4. I. 2. V I. 3. P 14.

The vent is situated nearly midway between the extremity of the snout and the insertion of the caudal fin.

The lateral line is quite conspicuous even on the tail, where it is reduced to cutaneous pores. Its fall on the peduncle of the tail is convex upwards, and rather near the caudal fin.

The ground color appears to have been olivaceous yellow, marbled with black, the marblings extending likewise to the fins.

For a specimen of four inches, that which we have had figured, we are indebted to the kindness of Rev. Z. Thompson, of Burlington, to whom it was presented by Mr. Ransom Colberth, who caught it in June, 1844, while fishing for the Brook Trout in a branch of Lamoille River, in the town of Johnson, Lamoille County (Vt.). The Lamoille River empties into Lake Champlain, about ten miles north of Burlington. This species, therefore, ranges west of the Green Mountains.

XI. COTTUS BOLEOIDES, GIRARD.

PLATE II. Figs. 7 and 8.

Syn. *Cottus boleoides*, GIRARD, Proc. Amer. Assoc. Adv. of Sc. II., 1850, p. 411; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

Had the name of *gracilis* not been preoccupied to designate another species of this genus, the one here referred to would have deserved it with great propriety.

Indeed, although of medium size, it is slender and elongated. The outline of the head and back is regular and slightly arched; that of the lower part of the head and belly is nearly straight. The sides are full and rounded. The body is consequently subfusiform. Its greatest depth is contained six times and a half in the total length, while the least depth, in advance of the caudal, enters in it nearly twenty times. The thickness is one-fifth less than the depth.

The head forms a little less than the fourth of the total length; it is nearly as deep as broad, but its length is much greater than its width. Its upper surface back of the eyes is slightly flattened; the anterior part slopes quite rapidly, rendering the snout very obtuse; the jaws are rounded and of equal length. The mouth is proportionally broad; when it is shut, the posterior extremities of the maxillaries extend to a line passing through the pupil. The eyes are very large and subcircular; their longitudinal diameter is contained only four times in the length of the head. They come very near each other on the frontal line, and are separated by a very narrow space, narrower than in any other species. The anterior

nostrils are a little nearer the orbit than the end of the snout. The preopercular spine is very acute, although stout at its base, and directed obliquely upwards; the spine on the subopercular is very minute. The gill openings are large and oblique; the isthmus is only three-sixteenths of an inch wide.

The fins in this species are proportionally much more developed than in any other within our knowledge. The pectorals, especially, would soon recall to mind the different kinds of flying fish. The origin of the first dorsal is placed seven-eighths of an inch from the end of the snout. It is very convex; there are eight or nine rays on a base of half an inch, the first one being the shortest. The greatest height of that fin is not quite a quarter of an inch. The second dorsal is considerably higher than the first, and twice as long, and is composed of seventeen rays, all undivided. The anal commences under the second ray of the second dorsal, and terminates under the thirteenth; it is much higher than the latter, and also more convex. It contains sometimes eleven, and sometimes twelve undivided rays. The caudal is much elongated, posteriorly subtruncated, forming the fifth of the entire length. The eight middle rays bifurcate from the middle of their length, and it can scarcely be said that two of them exhibit a tendency to subdivide again near their extremity. The ventrals are inserted under the base of the pectorals, and in advance of the first dorsal; they reach, and even extend beyond the vent when bent backwards. Amongst the three soft rays, the middle one is the longest, and the internal one, the shortest. The insertion of the pectorals is very oblique, and crescentic; their form is elliptic or oval, quite regular, and their tip, when directed backwards, reaches the fourth ray of the anal, and the sixth of the second dorsal. All the rays are undivided; the seven inferior ones are much stouter, and extend beyond their membrane.

Br. 6. D VIII or IX.—17. A 11 or 12. C 2. I. 4. 4. I. 2. V I. 3. P 14.

The vent is placed midway between the extremity of the snout and the base of the caudal fin, as in the preceding species.

The lateral line is rectilinear, disappearing already under the tenth ray of the second dorsal; but the minute pores, which mark its continuation to the caudal, become very indistinct, running in a straight line, always nearer the back, when a gradual fall brings it on the middle of the peduncle of the tail; five or six very large pores are seen on each side underneath along the lower jaw. These, as we have seen above, belong to that cephalic channel of the lateral line, which, from the occipital region, passes down into the preopercular and lower jaw. The same pores exist in the other species, but nowhere did we find them so conspicuous.

The remains of coloration left on such specimens as have been preserved in alcohol, indicate a grayish ground above, turning to yellowish underneath. The top of the head, and upper part of the body, are scattered all over with small, well-defined dots of black, of the size of a pin's head; the sides and tail exhibit large and irregular brown patches, surrounded by an orange tint, which becomes the predominant color of the lower part of the body. The pectorals, dorsals, and caudal, are slightly banded and dotted with black like the body itself.

A series of individuals of this species, the largest of which had three inches and

a quarter, was first collected at Windsor (Vt.), by Ed. Cabot, Esq., of Boston. Dr. D. H. Storer had in his possession two small ones from the same vicinities.

Specimens are preserved in Prof. Agassiz's Cabinet, and at the Smithsonian Institution.

XII. *COTTUS FORMOSUS*, GIRARD.

Amongst the macerated remains of *Trigloporus Thompsonii*, described further on, we detected the body of a *Cottus*, in a similarly mutilated state. After instituting all the comparisons which could possibly be made, we became fully satisfied that we had to deal with a distinct and undescribed species, although not quite prepared to give a full and satisfactory description of it. Its most striking peculiarities are a small head, a slender and graceful body, with the two dorsals widely separated. The entire length, from the snout to the extremity of the caudal fin, is three inches and a quarter, in which length the head enters for about the fifth part. The upper surface of the head is very flat, and the eyes of medium size, circular, and very proportionate. The anterior and inferior part of the head are destroyed in the specimen under examination, so that we are at a loss to describe the nostrils, the shape of the mouth, the isthmus, as well as to state how many times the diameter of the eye is contained in the length of the head. The preopercular spine is stout and rather short, acute, and curved. There exists on the same bone a small spine, situated under the first, and directed obliquely downwards and backwards. The subopercular spine is well developed, acute, and curved upwards, being as usual directed forwards. The greatest thickness, and depth of the body cannot be given under the existing circumstances; but the least depth, taken on the peduncle of the tail, is contained nearly eighteen times in the total length, being about three-sixteenths of an inch. The body itself seems to have been regularly fusiform.

The anterior edge of the first dorsal is situated at thirteen-sixteenths of an inch from the snout. It is composed of eight rays, extending on a basis of half an inch. Its upper edge is regularly arched. The second dorsal is separated from the first by a space of nearly a quarter of an inch, filled by a membrane which extends between both fins. The rays, sixteen in number, are very slender and unbranched, the two anterior ones shorter than the third. There is a free space of a quarter of an inch between the posterior end of the second dorsal and the base of the caudal fin. The caudal itself is rounded posteriorly, convex, composed of eleven rays, and a few rudimentary ones; those of the middle of the fin, are branched towards their extremity; its length is contained six times and a half in the total length. The origin of the anal takes place under the third ray of the second dorsal, and leaves a space of nearly half an inch between its posterior end and the beginning of the caudal. The ventrals are situated under the pectorals, in advance of the anterior dorsal; when bent backwards, they are very far from reaching the vent. The base of the pectorals is crescent-shaped and very close to the gill openings. These fins are rather short, composed of twelve or thirteen unbranched rays, and when bent

backwards, their tips do not reach the posterior margin of the first dorsal, and consequently not the anterior margin of the anal.

Br. 6. D VIII.—16. A 11. C 2. I. 5. 4. I. 1. V I. 3. P 12.

The lateral line runs straight, and near the back. It passes into the series of minute pores before it reaches the end of the second dorsal, and its fall on the peduncle of the tail is indicated by a slight undulation. The cephalic channels appear to be very much developed, perhaps more so than in any other species of the genus, if we judge of them by the wide duct which passes through the preopercular.

The vent is nearer the base of the caudal than the end of the snout.

Nothing can be said about the color, on account of the circumstances under which the specimen was found.

The species inhabits Lake Ontario, in the vicinity of Oswego (N. Y.), in company with *Trigloporus Thompsonii*, constituting a part of the food of *Lota maculosa*.

The only specimen hitherto known of this species was collected by Prof. Baird, and is now preserved at the Smithsonian Institution.

XIII. COTTUS FABRICII, GIRARD.

Syn. *Cottus Fabricii*, GIRARD, Proc. Amer. Assoc. Adv. Sc. II., 1850, p. 411; and, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 189.

Cottus gobio, FABR. Faun. Grœnl. 1780, p. 159.

Cottus tricuspidis (Mus. Reg.). GRAAH, Reise Östk. Grönl. 1832, p. 194.

In the Fauna of Greenland, we find one species of true *Cottus*, identified by O. Fabricius with *C. gobio* of the authors of Northern Europe. But there would be a very remarkable peculiarity in the habits of this species, if it be true that it lives in company with *Acanthocottus scorpius* and *scorpioides*, and consequently in salt water. We are not prepared to tell how far fresh water Cotti may be accommodated in a saline medium, but it seems to us much more probable that the Greenland *Acanthocottus* themselves, like those of New England, leave the sea at a certain season, ascend the fresh water inlets, and then may be found in company with the Greenland Miller's Thumb. On the other hand, if we take into account the reduced saltiness of the Arctic Sea, we can easily conceive how a fresh water fish may occur at the entrance of streams or rivulets emptying into the bays. If in the Temperate Zone, the Miller's Thumbs keep far away from the sea-shore, in the Arctic Zone, they may reach the sea without extending into its depth.

At any rate we have here a true *Cottus*, since Fabricius, who could not be mistaken respecting *C. gobio*, identifies it with the latter. Besides, his diagnosis leaves no doubts on the subject, "smooth with two spines on the head." Now this may be said of all the species of the genus without exception. Then, without giving its size, he tells us that it is much smaller than the *Cottus* (*Acanthocottus*) *scorpius* and *scorpioides*. Although very similar to *C. gobio*, we consider it as a distinct species. And if Fabricius be correct in the formula of the fins, we notice a fact which excludes at once the idea of identity with either *C. cognatus* or *C. Richardsonii*;

it is the presence of three soft rays to the ventral fins. It cannot be identified with *C. Franklinii*, although the ventrals of the latter possess only three soft rays; nor is it the *C. affinis* of Scandinavia which has again one soft ray more to its ventrals. Although the absolute number of the rays of the other fins does not constitute a specific character of unvariable constancy, that number is so peculiar in this case that it can be provisionally taken into account until the study of this species can be completed hereafter.

Br. 6 D X.—17. A 18. C 12. V I. 3. P 19.

Oth. Fabricius adds nothing special on the structure of the fins. He says that both dorsals are contiguous by a low membrane. This is the case with nearly all the Cotti and many Acanthocotti. We quote from his description the following details respecting the coloration. "The iris is silvery. The skin smooth, with a somewhat rough lateral line; sometimes the region behind the eyes and beneath the pectoral fins is also rough. Color of the back blackish, the sides white spotted. The belly paler, with white spots, which are silvery behind the anus. The breast and under part of the tail are white. Pectoral fins blackish, sinuated by a paler coloration, with their lower margin red. Second dorsal of the same color, but not bordered with red. First dorsal blackish. Ventrals white, with reddish spots. Anal reddish. Caudal palish. The female differs by its belly being not spotted, below whiter, and yellow dark-spotted ventrals."

This coloration strikes us as much more similar to that of Acanthocotti than to anything we know amongst Cottus proper.

The same author says that this species frequents sandy and argillaceous bottoms, and that its food consists of fishes (Ammodytes), holothuria (*H. priapus*), marine worms, and others living in the sand and clay.

The female deposits her white eggs amongst the Ulva, where they are watched by the male, as is the case with the lump fish and *A. scorpioides*.

That the lump fish (*Lumpus anglorum*) on the coasts of New England watches its eggs we have been often told by fishermen. We never heard whether sculpins (Acanthocotti) did the same.

At any rate nothing of the kind has, as yet, been observed amongst Cottus proper, and thus there would be in the history of this species a peculiarity unknown in the others, and which recalls to mind analogous facts observed amongst European sticklebacks.

CHAPTER IV.

ON THE GENUS COTTOPSIS, Girard.

WE have proposed this genus¹ for the reception of one species placed by its author in the genus *Cottus*, at the time when the latter still included the marine species. It differs both from *Cottus* and *Acanthocottus*. By its large size it recalls to mind the marine species, and by its smooth head, the species of the fresh water. Its physiognomy, as a whole, partakes of both of these groups. Yet as it belongs to the fluviatile fauna, it is more nearly related to the fresh water species by its first dorsal lower than the second, by the structure of the other fins, the opercular apparatus, and the shape of the mouth.

The characters of the genus *Cottopsis* may thus be expressed: General form regular, fusiform, or subcylindrical. Body covered with a skin beset with prickles, instead of being smooth and scaleless. Head deeper than broad; shape of the head and cleft of mouth like those of *Cottus*. A preopercular spine only on each side; card-like teeth on the palatine bones.

The obtuse head, the cleft of the mouth, which does not extend beyond the eyes, the first dorsal lower than the second, and the prickly skin, are the essential characters by which this genus is distinguished from *Acanthocottus*, whilst the palatine teeth and the dermic prickles constitute its difference from *Cottus* proper. We have mentioned that in some *Cotti* teeth began to be perceived on the palatines, which character we consider as an approximation towards the *Cottopsis*, in which those teeth are fully developed, and perhaps more so in the adult than in the immature state.

Sir John Richardson foresaw the necessity of withdrawing one day the species here referred to from the genus *Cottus*, and suggested² that it would very likely be brought into the genus *Hemilepidotus*, on the ground perhaps of the presence in the latter of palatine teeth. But, as he remarks himself, *Hemilepidoti* have the body partly covered with scales, whilst in this case the skin is provided with prickles of a peculiar character. The spiny head of *Hemilepidotus*, as well as the fact that it is an inhabitant of the sea, bring that genus nearer the *Acanthocotti*, and is to the latter what *Cottopsis* is to *Cotti*. On the other hand, the unique dorsal of *Hemilepidoti* and their palatine teeth, indicate a closer relationship with *Scorpena*, also a marine genus.

¹ Proc. Bost. Soc. Nat. Hist., iii., 1851, p. 303.

² Fauna Boreali-Americana, iii., 1836, p. 313.

Mr. Heckel has placed the *C. asper* in his genus *Trachidermis*, to which it bears only analogies and no true affinities. The genera *Trachidermis* and *Cottopsis* have both a rough or prickly skin, and teeth on the palatine bones; but *Trachidermis* has the first dorsal, the mouth, the opercular spines, and the general shape of head and body, of *Acanthocotti*. *Cottopsis* has the first dorsal, the mouth, the opercular spine, the general shape of the head and body, of *Cotti*. The genus *Trachidermis* is the diminutive of *Acanthocotti*, provided with a rough skin and teeth on the palatines. The genus *Cottopsis*, on the other hand, is the amplification of *Cotti*, provided with a rough skin, and teeth on the palatine bones.

Besides all this, *Trachidermis* belongs to the marine tribe. Its relationships are complete.

Some time since, Sir John Richardson made the genus *Centridermichthys*¹ to include two cottoids of the seas of China and Japan, with which he proposed to associate his *C. asper*. But *Centridermichthys* we have shown to be identical with *Trachidermis*, in which the marine species must be placed.

COTTOPSIS ASPER, GIRARD.

Syn. *Cottopsis asper*, GIRARD, Proc. Bost. Soc. Nat. Hist. III., 1850, p. 303.

Cottus asper, RICH. Faun. Bor. Amer. III., 1836, pp. 295, 313. Pl. 95, Fig. 1.

Trachidermis Richardsonii, HECK. Ann. d. Wien. Mus. II., 1837, p. 162.

Centridermichthys asper, RICH. Ichth. of the Voy. of the Sulphur, 1844, p. 76.

This fish we know only through the description and figures given by Sir John Richardson. Its ordinary size is from nine to ten inches, surpassing thus in size all the fresh water species of the genus *Cottus*. To judge of the general form from the profile view, the body would appear quite regular, diminishing gradually in depth from before backwards. The back and belly are nearly straight and very regular, until the termination of the dorsal and anal fins.

The head forms the third of the length, the caudal fin excluded. Its upper surface is flattened or rather widely concave, without the least trace of ridges, tubercles, or spines. The inferior lip projects a little beyond the superior one when both jaws are brought close together. The mouth is broad, but not deeply cleft. The palatine bones are furnished with teeth similar to those on the vomer, premaxillaries, and dentaries.

The eyes are of medium size, and placed near the summit of the head; yet the distance which separates them above is more than one of their diameter. The nostrils, situated on the same horizontal line with the eyes, are small and a little nearer the snout than the orbit.

The opercular apparatus, as far at least as we could understand it, does not appear to differ much from that of *Cotti*. None of its constituent pieces are serrated or provided with spines on their edge. The convexity of the preopercular is armed with an acute spine, slightly curved upwards and covered by the skin so

¹ Ichthyology of the Voyage of the "Sulphur," 1844, p. 74.

as scarcely to be seen exteriorly. The inferior edge of the preopercular terminates in two distinct angular points. Finally the scapular is terminated by an acute point which is concealed under the skin, and perceptible only to the touch.

"There are no scales; the skin on the head is smooth to the touch, but dotted on the crown with minute soft warts. The belly, a stripe adjoining the anal on each side, a small space around the base of the caudal, and the interscapular space anterior to the first dorsal, are also smooth; but the rest of the skin of the body is thickly studded with very small subulate, acute spines directed backwards. These spines are too minute to be seen distinctly with the naked eye; but a little fold of skin, raised by each of them, produces a roughness which is very visible; they resist the finger only when it is drawn against their points."

"The lateral line, formed by a furrow, interrupted by about forty-four contractions, is very conspicuous."—RICHARDSON.

The origin of the first dorsal is opposite the base of the upper ray of the pectorals; it is much lower than the second, to which it is connected by means of a membrane. The sixth and seventh rays are the longest. The second dorsal commences opposite the anus, and extends a little farther back than the anal, as is usually the case in Cotti. The anal is proportionally lower than in Cotti, and, therefore, much lower than the second dorsal, if we judge of it by the figure given in the *Fauna Boreali-Americana*. The caudal is slightly rounded posteriorly, whilst its base of insertion is somewhat dilated or spread out. The peduncle of the tail is quite narrow. The ventrals are situated under the pectorals as in Cotti. There exists an anterior bony ray, and four soft but unbranched ones. The pectorals are obliquely suboval, and their rays unbranched.

Br. 6. D IX.—21. A 18. C 6. I. 4. 3. I. 6. V I. 4. P 16.

This species, according to Dr. Gairdner, is quite common in the Columbia River. To him Dr. Richardson was indebted for the specimens from which his description was drawn and the figures made. Specimens were collected by the United States Exploring Expedition.

For our description of this species, as well as of *C. cognatus*, we are indebted to the *Fauna Boreali-Americana*.

CHAPTER V.

ON THE GENUS TRIGLOPSIS,¹ Girard.

THERE are animals whose organization is specially adapted for the depths, and which are never or but seldom seen or met with at the edges of the water, on the sea beaches, or else on the shores of the lakes. The iron dredge has brought to light many such.

There is another way of securing the inhabitants of the deep bottoms, which consists in opening the stomachs of the large wandering kinds, as they generally feed upon the small and inoffensive ones. The sole difficulty in this case is the digestive power of that organ, which in a short time has destroyed all the soft and delicate parts, the ornament of the solid frame, either bony or calcareous.

The generic feature of *Triglopsis* does not consist in the possession of characters peculiar to itself alone, but rather in the association of characters which may individually be found to exist in other genera, and from whose combination results its peculiar physiognomy.

The general form of the head and body reminds us of the genus *Trigla*; by its smooth head, the structure of the mouth, and the first dorsal lower than the second it approaches *Cotti*; the elongated snout and head, and the presence of several spines on the preopercular, is an approximation towards *Acanthocotti*. The genus differs—from *Trigla*, by a smooth head and body, the first not being cuirassed, and the second not scaled, and by the first dorsal fin which is lower than the second;—from *Acanthocottus*, by the want of spines on the head, which, as stated, is smooth; also by the first dorsal lower than the second, and by the shape of the mouth, the angles of which do not extend back of the eyes; and if it appear more deeply cleft than in *Cottus*, it is owing to the fact that the snout is pointed instead of being truncated;—from *Cottus* it differs by its elongated snout and the presence of several spines on the preopercular, on the one hand, and by its more slender head and body, on the other. It is still more widely distinct from *Cottopsis*, with which it has no other affinities except those which entitle it to a place in the same family.

Although our genus *Triglopsis* has no generic character belonging exclusively to it, it is important that we should recapitulate all those which we have just enumerated, in connection with the genera which partake of some of them. Body and

¹ Proc. Bost. Soc. Nat. Hist. iv., 1851, p. 18.

head slender and elongated, the former tapering quite rapidly away towards the tail; both covered with a smooth skin; no teeth on the palatine bones; cleft of the mouth not extending beyond the eye; preopercular exhibiting four equal, needle-like, and very delicate spines. The first dorsal fin is separated from the second by a considerable space, and is much the lower. The great development of the second dorsal and the very large eyes might become a specific feature if other species were to be discovered hereafter, for which reason we would not mention them as of generic value. The lateral line, the perfectly smooth skin, and the absence of an isthmus may become as many generic characters.

The structure of the skull of *Trigloopsis* exhibits the remarkable character of having hollow channels, hitherto only known to exist in *Sciaenoids*, and considered as a characteristic of this group. We now find amongst Cottoids a similar structure, but much less developed in *Cotti* and *Acanthocotti*, in which we had overlooked it, before we knew the genus *Trigloopsis*.

This anatomical peculiarity indicates quite a near relationship between Cottoids and *Sciaenoids*. The representatives of the latter family in this country are all marine, but one.

TRIGLOPSIS THOMPSONII, GIRARD.

PLATE II. Figs. 9 and 10.

Syn. *Trigloopsis Thompsonii*, GIRARD, Proc. Bost. Soc. Nat. Hist. IV., 1851, p. 19.

It will be easy to form a correct idea of the general form of this species by the accompanying figures, which, although a restoration from several incomplete individuals, we are confident represent its specific features.

The head is elongated, tapering towards the snout, as the body tapers towards the tail. It forms more than the third, and not quite the fourth of the entire length. Its upper surface is smooth, gradually sloping towards the snout. Its greatest depth is contained twice in its length; whilst its greatest width forms only the two-thirds of the latter dimension. The snout is elongated, and thus the mouth, which does not extend beyond the entire pupil, is more deeply cleft than in *Cotti*. The lower jaw is slightly longer than the upper. The teeth are very minute, proportionally more so than in *Cotti*. They do not exist on the palatines, but the vomer, besides the crescentic band in front, is provided with a narrow strip of similar teeth along the middle line of the posterior branch of that bone. The eyes are very large and elliptical; their longitudinal diameter is contained four times in the length of the head, the same proportion as in many *Cotti*, but here the head is much more elongated, and accounts for the proportionally greater size of these organs in *Trigloopsis*. The anterior nostrils are nearer the orbit than the snout; the posterior one is higher up on the frontal line, and still nearer the eye. Both pairs of these openings appear to be tubuliform, but the decomposed state of the specimens did not permit entire satisfaction on that point. The sides of the head are as smooth as the upper surface. The preopercular is the only bone of this

region provided with spines, and the latter are comparatively smaller and more slender than amongst Cotti. There exist usually four of these spines, the uppermost, the strongest, directed obliquely upwards. The second is directed backwards; the third and fourth, the smallest, downwards. The branchiostegals are six in number, as in Cotti and Acanthocotti. The gill openings extend from the head obliquely down, each meeting its fellow from the opposite side under the medial line of the head, so that there exists no isthmus at all.

The greatest depth of the body is a little more than that of the head, and contained nearly seven times in the entire length of the fish. The least depth on the peduncle of the tail enters in the same length nearly twenty-three times, six times in the length of the head, fourteen times in that of the body, and nearly three in that of the caudal fin. The thickness is less than the depth, and diminishes very rapidly backwards.

The origin of the anterior dorsal is one inch and three-eighths distant from the end of the snout. It is composed of seven rays with a basis of half an inch. The first and last rays are the smallest, and nearly equal the one to the other. The second, third, and fourth are much higher, and of nearly equal length also. The second dorsal, much higher, is separated from the first by a space of three-sixteenths of an inch. Its anterior ray is not higher than the last of the anterior dorsal; its greatest height is three times that of the latter. Its shape is angular. It is composed of eighteen slender and undivided rays. The anal commences slightly in advance of the second dorsal; is about half the height of the latter, uniformly convex on its outer margin, and composed of fifteen rays, all undivided, the last one opposed to the fifteenth of the second dorsal. The caudal is rounded posteriorly, with ten well developed rays, eight of which are bifurcated. The ventrals are inserted under the pectorals, and in advance of the anterior dorsal, as in Cotti. They are composed of three soft rays and a spiny one, and when bent backwards, do not reach the anus. The insertion of the pectorals is crescentic and close to the gill openings. These fins are not quite as long as the head, and contain sixteen rays all undivided, the tip of the longest reaching nearly to the second ray of second dorsal and of the anal.

Br. 6. D VII.—18. A 15. C 1. I. 4. 4. I. 1. V 1. 3. P 16.

The anus is at a distance of three-sixteenths of an inch from the first ray of the anal and situated almost midway between the tip of the snout and the base of the caudal fin, though a little more distant from the former. The lateral line is very much developed and very conspicuous until the eighth ray of the second dorsal, where it becomes less distinct, although running to the base of the caudal fin. The skin is perfectly smooth.

The ground color is uniform pale greenish-yellow, dotted and maculated with black or brown on the head, back, and sides. The caudal, pectoral, and dorsal fins are banded; the anal and ventrals, unicolor.

This species inhabits somewhere in the depths of Lake Ontario, but has not yet been seen or caught alive, either by fishermen, or by naturalists. The manner

in which its discovery took place we have already related.¹ In opening the stomach of the Ling (*Lota maculosa*), the fishermen of Oswego finding it almost constantly filled with that fish, had entertained the erroneous opinion that the Ling swallowed its progeny. Professor Baird, who visited that place in 1850, and heard the story, secured specimens, which at once enabled him to recognize in them a fish new to science although half digested, the skin and the fins in most cases destroyed. In that state, when the head and body alone have preserved their shape, the elongation of the former, and the tapering away of the latter, may remind superficial observers of the elongated head and the tapering body of *Lota maculosa*.

It is hoped that persons living in the vicinity of Oswego, will feel interested enough in the subject to secure to science complete specimens, and gather some information respecting its habits and home at large.

Its food consists chiefly of shrimps, of a species yet undescribed, as far as we have been enabled to ascertain by the examination of the remains in a very soft condition.

Attention should be directed on all the fishing-grounds of the Ling, to the contents of the stomachs of this fish, as at present the only way known of procuring Trigloporis. By this means, at least, we should become acquainted with its geographic distribution; for mere remains, when they cannot be mistaken, are always sufficient to establish its occurrence at any given place, should complete and fresh specimens escape all researches.

¹ Proc. Bost. Soc. Nat. History, iv., 1851, p. 18.

NOTE.

SINCE the foregoing pages have been put to press, a new fact touching the geographical distribution of *Cottus meridionalis*, has come to our knowledge, which is deemed of sufficient interest to be placed on immediate record here. This species has been found in one of the lower tributaries of the Potomac, in Rock Creek, Washington (D. C.). Consequently *C. meridionalis* occurs in the same hydrographical basin as *C. viscosus*.

It is well known that the aquatic fauna of the Southern States is very different, both from that of the Middle and that of the Northern. There are comparatively few species which occur throughout the Atlantic States of the Union. Still, faunas and floras, although circumscribed within particular provinces or districts, cannot be defined in their boundaries by mathematical lines, and we frequently find districts whose lines of demarkation overlap or interdigitate.

Now the State of Maryland seems to be placed on the limit, between the faunas of the Southern and Middle States, a fact which will make the study of its natural productions much more difficult, but at the same time of more than ordinary interest.

The locality, Rock Creek, Washington (D. C.), given at page 53 to *C. viscosus*, does not belong to the latter species, to which it was temporarily attributed before an examination of the specimens could be made critically. After this was effected, an oversight has allowed it to remain there.

DIAGNOSIS
OF THE
GENERA AND SPECIES
CONTAINED IN THIS
MONOGRAPH.

COTTUS, Artedi.—Upper surface of head, smooth. One small spine on the side of the head; sometimes a second still smaller below, and occasionally a third of the size of the second. First dorsal fin lower than the second. Palatine teeth none, or rudimentary. Cleft of mouth not extending beyond the orbits. Six branchiostegal rays.

I. Rays of ventral fins, five in number.

Cottus cognatus, Rich.—Body fusiform. Origin of anal fin opposite to sixth ray of second dorsal. Pectorals equalling the head in length. Anus situated nearer the snout than the base of caudal fin.

Cottus Richardsonii, Agass.—Body fusiform. Origin of anal fin opposite to third ray of second dorsal. Pectoral fins shorter than the head. Anus situated midway between the snout and tip of caudal fin. Insertion of ventrals in advance of the anterior dorsal, and near the lower edge of pectorals.

Cottus Wilsonii, Grd.—Body fusiform. Upper rays of pectoral fins, branched; their tip reaching the anterior margin of second dorsal fin. Insertion of ventral fins under the middle of pectorals, and in advance of the anterior dorsal.

Cottus Bairdii, Grd.—Body fusiform. First dorsal fin very low. Tip of pectorals extending be-

DIAGNOSIS
GENERUM ET SPECIERUM
IN HOC
MONOGRAPHIO
DESCRIPTORUM.

COTTUS, Artedi.—Capitis superficie levi; spinâ parvâ ex capitis latere utroque, interdum alterâ aliquanto minore, infra positâ, et nonnunquam tertia magnitudine æquali secundæ. Pinna dorsali prima brevior secundâ. Dentibus palatinis nullis, vel eorum rudimentis tantum. Oris fissura ultra orbitas non porrectâ. Radiis branchiostegis sex.

I. Pinnarum ventralium radiis, quinque.

Cottus cognatus, Rich.—Corpore fusiforme. Origine pinnae analis ex adverso sexto secundæ pinnae dorsalis radio. Pinnis ventralibus capite longitudine æqualibus. Ano propius rostrum quam pinnae caudalis basim posito.

Cottus Richardsonii, Agass.—Corpore fusiforme. Origine pinnae analis ex adverso tertio secundæ pinnae dorsalis radio. Pinnis pectoralibus capite brevioribus. Ano medio inter rostrum et pinnae caudalis extremitatem. Pinnis ventralibus ante dorsalem anteriorem et prope inferiorem pectoralium marginem, insertis.

Cottus Wilsonii, Grd.—Corpore fusiforme. Superioribus pinnarum pectoralium radiis divisus, eorumque extremitate ad anteriorem pinnae dorsalis secundæ marginem porrectâ. Pinnis ventralibus sub pectoralium medio et ante dorsalem anteriorem, insertis.

Cottus Bairdii, Grd.—Corpore fusiforme. Pinnâ dorsali primâ admodum brevi. Extremitati-

yond the anterior margin of the anal. Insertion of ventrals under the anterior margin of first dorsal, and behind the pectorals.

Cottus Alvordii, Grd.—Body stout and short, tapering rapidly away. A second preopercular spine, very minute. Origin of anal fin opposite the third ray of second dorsal. Tip of pectorals extending beyond the anterior margin of the second dorsal and anal fins. Insertion of ventrals near the lower edge of pectorals, in advance of the anterior dorsal.

Cottus meridionalis, Grd.—Body stout and short. A second and third, very minute spines on the preopercular. Origin of anal fin opposite to fourth ray of second dorsal. Tip of pectorals not reaching the anal. Insertion of ventrals even with the lower edge of the pectorals, in advance of the anterior dorsal.

II. Rays of ventral fins, four in number.

Cottus gracilis, Heck.—Body fusiform. Tip of pectoral fins extending beyond the fourth ray of second dorsal, and first of anal fin. Occasional palatine teeth. Insertion of ventrals under the pectorals, and in advance of anterior dorsal.

Cottus viscosus, Hald.—Body subcylindrical, stout. Tip of pectorals not reaching the anterior margin of the anal. Insertion of ventrals behind the pectorals, and in advance of the anterior dorsal.

Cottus Franklinii, Agass.—Body nearly cylindrical. Tip of pectoral fins not reaching the anterior margin of second dorsal. Insertion of ventrals in advance of the anterior dorsal, and under the middle of pectorals.

Cottus gobioides, Grd.—Body subcylindrical. Tip of pectoral fins not reaching the anal. Insertion of ventrals under the upper edge of the pectorals.

Cottus bolcoides, Grd.—Body fusiform, slender. Tip of pectoral fins extending beyond the fifth ray of second dorsal, and third of anal, fins.

bus pinnarum pectoralium ultra anteriorem pinnæ analis marginem prolatis. Pinnis ventralibus sub anteriorem marginem pinnæ dorsalis primæ et post pectorales, insertis.

Cottus Alvordii, Grd.—Corpore crasso brevique citò decrescente. Altera spina præoperculari, admodum parva. Origine pinnæ analis posita ex adverso tertio pinnæ dorsalis secundæ radio. Extremitatibus pinnarum pectoralium ultra anteriorem pinnarum dorsalis secundæ et analis marginem porrectis. Pinnis ventralibus prope inferiorem pectoralium marginem et ante dorsalem anteriorem, insertis.

Cottus meridionalis, Grd.—Corpore crasso brevique. Spina minima secunda atque tertia supra præopercularem. Origine pinnæ analis ex adverso quarto dorsalis secundæ radio. Extremitatibus pinnarum pectoralium non porrectis ad pinnam analem. Pinnis ventralibus in eadem lineâ quâ pectorales, et ante dorsalem anteriorem, insertis.

II. Pinnarum pectoralium radiis, quatuor.

Cottus gracilis, Heck.—Corpore fusiforme. Extremitatibus pinnarum pectoralium ultra quartum pinnæ dorsalis secundæ et primum analis radium porrectis. Dentibus palatinis aliquando occurrentibus. Pinnis ventralibus sub pectorales et ante dorsalem anteriorem, insertis.

Cottus viscosus, Hald.—Corpore subcylindrico, crasso. Extremitatibus pinnarum pectoralium non porrectis ad anteriorem pinnæ analis marginem. Pinnis ventralibus post pectorales et ante dorsalem anteriorem, insertis.

Cottus Franklinii, Agass.—Corpore cylindrico. Extremitatibus pinnarum pectoralium non productis ad anteriorem pinnæ dorsalis secundæ marginem. Pinnis ventralibus ante dorsalem anteriorem et sub pectoralium medio, insertis.

Cottus gobioides, Grd.—Corpore subcylindrico. Extremitatibus pinnarum pectoralium non productis ad pinnam analem. Pinnis ventralibus sub superiorem pectoralium marginem, insertis.

Cottus bolcoides, Grd.—Corpore fusiforme, gracile. Extremitatibus pinnarum pectoralium ultra quintum pinnæ dorsalis secundæ, et tertium analis

Insertion of ventrals in advance of the anterior dorsal, near the lower edge of pectorals.

Cottus formosus, Grd.—Body fusiform. Tip of pectoral fins not reaching the anterior margin of second dorsal. A second minute preopercular spine, directed downwards.

Cottus Fabricii, Grd.—Head having a tendency to become tuberculous. First dorsal and pectoral fins composed of several rays more than in any other species of the genus.

COTTOPSIS, Grd.—Head smooth. One spine on the preopercular, bent backwards and upwards as in Cotti. First dorsal fin lower than the second. Teeth on the palatine bones. Skin beset with minute prickles.

Cottopsis asper, Grd.—Tip of pectoral fins reaching scarcely the anterior margin of the second dorsal. Anal fin low. Lateral line extending uninterruptedly from head to base of caudal fin.

TRIGLOPSIS, Grd.—Head smooth. First dorsal fin lower than the second. No teeth on the palatine bones. Several radiating spines on the edge of the preopercular. Skin smooth.

Trigloopsis Thompsonii, Grd.—First dorsal fin separated from the second by a considerable space. Second dorsal very elevated. Lateral line extending from head to the base of caudal fin.

radium porrectis. Pinnis ventralibus ante anteriorem dorsalem et prope inferiorem pectoralium marginem, insertis.

Cottus formosus, Grd.—Corpore fusiforme. Extremitatibus pinnarum pectoralium non productis ad anteriorem dorsalis secundæ marginem. Secundâ spina præoperculari minutâ deorsum directa.

Cottus Fabricii, Grd.—Capite ad tubercula habenda proclivi. Radii pinnarum dorsalium et pectoralium pluribus quàm ullâ specie hujus generis.

COTTOPSIS, Grd.—Capite levi. Unâ spinâ e præoperculari, flexa retrorsum et sursum, ut in Cotti. Pinna dorsali primâ brevior secundâ. Dentibus in ossibus palatinis. Cute minutis aculeis hirsuta.

Cottopsis asper, Grd.—Extremitatibus pinnarum pectoralium vix productis ad anteriorem secundæ pinnæ dorsalis marginem. Pinna anali brevi. Lineâ laterali non interruptâ a capite ad pinnæ caudalis basim.

TRIGLOPSIS, Grd.—Capite levi. Primâ dorsali pinnâ brevior secundâ. Dentibus ex ossibus palatinis nullis. Spinis compluribus radiantibus ex margine præopercularis. Cute levi.

Trigloopsis Thompsonii, Grd.—Pinnâ dorsali primâ a secunda spatio aliquanto sejuncta. Pinna dorsali secundâ altissimâ. Lineâ laterali a capite ad basim pinnæ caudalis porrectâ.

BIBLIOGRAPHY.

- AGASSIZ (Louis). Recherches sur les Poissons fossiles. Neuchâtel, 1833—1844. 5 vol. 4to., avec atlas folio.
- AGASSIZ (Louis). Lake Superior: its physical character, vegetation and animals, compared with those of other and similar regions. Boston, 1850, 8vo.
- ARTEDI (P.). Genera Piscium, in quibus systema totum ichthyologiæ proponitur, cum classibus, ordinibus, generum, characteribus, specierum differentiis, observationibus plurimis; redactis speciebus 242 ad genera 52. Lugd. Bat. 1738, 8vo.
- ARTEDI (P.). Descriptiones specierum Piscium quos vivos præsertim dissecuit et examinavit, inter quos primario Pisces regni sueciæ facile omnes accuratissime describuntur, cum non paucis aliis exoticis. Lugd. Bat. 1738, 8vo.
- ARTEDI (P.). Synonyma nominum Piscium fere omnium; in qua recensio fit nominum piscium, omnium facile authorum, qui unquam de Piscibus scripsere; uti Græcorum, Romanorum, Barbarorum, necnon omnium insequentium ichthyologorum. Lugd. Bat. 1738 (1793), 8vo.
- AYRES (W. O.). An attempt to prove that *Cottus cognatus* of Richardson, *Cottus viscosus* of Haldeman, and *Uranidca quiescens* of Dekay, are one species, and are identical with *Cottus gobio* of Linnæus. —Bost. Journ. of Nat. Hist. v., 1845, p. 116.
- BLOCH (M. El.). Allgemeine Naturgeschichte der Fische. Berlin, 1782—'95. Texte 4to., atlas folio. (*Ichthyologie ou Histoire naturelle générale et particulière des Poissons, avec des figures enluminées, dessinées d'après nature.* Berlin, 1785—'96, folio.)
- BONAPARTE (C. L.). Catalogo metodico dei Pesci Europei. Napoli, 1846, 4to.
- BONNATERRE. Tableau encyclopédique et méthodique des trois Règnes de la Nature. Ichthyologie, 1788—1790. Paris, 4to.
- BRICKWELL (John). The natural history of North Carolina, with an account of the trade, manners and customs of the Christians and Indians, inhabitants. Illustrated with copper plates, whereon are curiously engraved the map of the country, several strange beasts, birds, fishes, snakes, insects, trees, and plants, &c. Dublin, 1737, small 8vo.
- CUVIER (G.), et VALENCIENNES (A.). Histoire naturelle des Poissons. Paris, 1828—1848, 8vo.
- DEKAY (James E.). Zoology of New York, or the New York Fauna. Part IV., Fishes. Albany, 1842, 4to.

- DONOVAN (Edw.). The Natural History of British Fishes, including scientific and general descriptions of the most interesting species. London, 1802—1808. 5 vols. 8vo.
- EKSTRÖM (C. U.). Fiskarne i Mörkö Skärgård. 1831, 4to.—(*Die Fische in den Scheerer von Mörkö*. Berlin, 1835, 8vo.)
- FABRICIUS (Otho). Fauna Groenlandica, systematice sistens animalia Groenlandiæ occidentalis hactenus indagata, quod nomen specificum, triviale, vernaculumque, synonyma auctorum plurium, descriptionem, locum, victum, generationem, mores, usum capturanque singuli, prout detagendi occasio fuit, maximaque parte secundum proprias observationes. Hafniæ et Lipsiæ, 1780, 8vo.
- FLEMING (John). A History of British Animals, exhibiting the descriptive characters and systematical arrangement of the genera and species of Quadrapeds, Birds, Reptiles, Fishes, Mollusca, and Radiata of the United Kingdom; including the indigenous, extirpated, and extinct kinds; together with periodical and occasional visitants. Edinburgh, 1828, 8vo.
- FRIES (B. Fr.), and EKSTRÖM (C. U.). Scandinaviens Fiskar, målade efter lefwande exemplar och ridate på sten af *Wilh. van Wright*. Stockholm, 1836—'42, 4to.
- GIRARD (Charles). A Monograph of the Fresh Water Cottus of North America.—Proc. of the Amer. Assoc. for the Adv. of Sc., ii., 1850, p. 409.
- GIRARD (Charles). On the genus *Cottus* *Auct.*—Proc. of the Bost. Soc. of Nat. Hist., iii., 1850, p. 183.
- GIRARD (Charles). Additional Remarks on Cottoids.—Proc. Bost. Soc. Nat. Hist., iii., 1850, p. 302.
- GIRARD (Charles). On a new genus of American Cottoids.—Proc. Bost. Soc. Nat. Hist., iv., 1851, p. 18.
- GIRARD (Charles). Révision du genre *Cottus* des Auteurs.—Nouv. Mém. de la Soc. Helvét. des Sciences Naturelles, xii., 1851, 4to.
- GRAAH, see VAHL.
- HALDEMAN (S., S.). Supplement to number one of "A Monograph of the Limniades, or Fresh Water Univalve Shells of North America," containing descriptions of apparently new animals in different classes, and the names and characters of the subgenera in *Paludina* and *Anculosa*. 1840, 8vo.
- HECKEL (J. Jakob). Ichthyologische Beiträge zu den Familien der Cottoiden, Scorpaenoiden, Gobioiden und Cyprinoiden.—Ann. des Wiener Museums der Naturgeschichte, ii., 1837, p. 143.
- JENYNS (Leonhard). A Manual of British Vertebrate Animals: or descriptions of all the animals belonging to the classes Mammalia, Aves, Reptilia, Amphibia, and Pisces, which have been hitherto observed in the British Islands; including the domesticated, naturalized, and extirpated species: the whole systematically arranged. Cambridge, 1835, 8vo.
- KIRTLAND (Jared P.). Descriptions of the Fishes of Lake Erie, the Ohio River, and their Tributaries.—Bost. Journ. of Nat. Hist., v., 1847, p. 330.
- LACEPEDE. Histoire Naturelle des Poissons. Paris, 1800, 4to. ed., 1819, 8vo.
- LINNÆUS (Car. A.). Fauna suecica sistens animalia sueciæ regni: Quadrapeda, Aves, Amphibia, Pisces, Insecta, Vermes, distributa per classes et ordines, genera et species. Cum differentiis specierum, synonymis auctorum, nominibus incolarum, locis habitationum, descriptionibus Insectorum. Stockholmæ, 1746, 8vo.

- LINNÆUS (Car. A.). *Systema Naturæ, sive regna tria naturæ systematice proposita per classes, ordines, genera et species.* Ed. xii., 1766.
- NILSSON (Sven). *Prodromus ichthyologiæ scandinavicæ.* Lundæ, 1832, 8vo.
- PALLAS (P. S.). *Zoographia Rosso-Asiatica, sistens omnium animalium in extense imperio Rossico et adjacentibus maribus observatorum recensioem, domicilia, mores et descriptiones, anatomen atque icones plurimum.* Petropoli, 1811 (1831).
- PENNANT (Th.). *Zoologia Britannica, tabulis æneis 152 illustrata.* London, 1776.
- REISINGER. *Ichthyologiæ Hungariæ.* Pestini, 8vo., 1830.
- RETZIUS (A. J.). *Fauna sueciæ a Carolo Linneo inchoata. Ps. I. Sistens Mammalia, Aves, Amphibia, et Pisces Sueciæ, quam recognovit, emendavit et auxit, &c.* Lipsiæ, 1800, 8vo.
- RICHARDSON (John). *Fauna Boreali-Americana; or the Zoology of the northern parts of British America: containing descriptions of the objects of natural history collected on the late northern land expeditions under command of Capt. Sir John Franklin.* London, iii., 1836, 4to.
- RICHARDSON (John). *Voyage of H. M. S. Sulphur. Ichthyology.* 1844, 4to.
- RICHARDSON (John). *Report on the Ichthyology of the Seas of China and Japan.* 1846, 8vo.
- RISso (A.). *Histoire naturelle des principales productions de l'Europe méridionale et particulièrement de celles des environs de Nice et des Alpes maritimes.* Paris, 1826, 8vo.
- SCHLEFER (M.). *Moselfauna, oder Handbuch der Zoologie, enthaltend die Aufzählung und Beschreibung der im Reg. Bezirke Trier beobachteten Thiere, mit Berücksichtigungen der angrenzen des Mosel departements und Belgiens.* Trier, 1844, 8vo.
- SELYS-LONGCHAMPS (Edm.). *Faune Belge, 1^{re} Partie, indication méthodique des Mammifères, Oiseaux, Reptiles et Poissons observés jusqu' ici en Belgique.* Liège, 1842, 8vo.
- SHAW (Geo.). *General Zoology, or systematic natural history, with plates from the first authorities and most select specimens, engraved principally by Heath.* London, 1800—'19.
- STORER (D. H.). *A Synopsis of the Fishes of North America.* Cambridge, 1846, 4to.—Mem. of the Amer. Academy, 1846.
- SWAINSON (W.). *On the Natural History and Classification of Fishes, Amphibians, and Reptiles.* London, 1838, 12mo.
- VAHL. In *Graah, Undersøgelses-Reise till Östkysten af Grönland efter kongelig Befaling udfort i Uarene, 1828—31.* Kiöbenhavn, 1832, 4to. (*Narrative of an Expedition to the East Coast of Greenland, sent by order of the King of Denmark, in search of the Lost Colonies, under the command of Captain W. A. Graah. Translated by G. Gordon Macdougall.* London, 1837, 8vo.)
- YARRELL (Wm.). *A History of British Fishes.* London, 1836, 8vo. Second ed. 1841.

EXPLANATION OF THE PLATES.

PLATE I, and Figs. 1—10 of PLATE II, need no further explanation beyond what is written at the bottom of those plates.

PLATE II, Fig. 11, represents the skeleton of *Trigloporus Thompsonii*. At pages 21, 22, we have alluded to some deficiencies in the general figure. The numbers appended to the bones of the face, as well as the initials, are those adopted by Prof. Owen. The numbers 1—12, which accompany the vertebrae, do not indicate their number in the series; we have allowed these numbers to be affixed in order to be more precise in alluding to any one of them. All these pieces have been homologized with those of *Cottus viscosus* on Plate III, of which a table is given immediately below.

PLATE III, Figs. 1—3, represent the muscular masses of *C. viscosus*, and the peculiar bendings of the myocomma, seen in profile in Fig. 1, from the belly in Fig. 2, and from above in Fig. 3.—Fig. 4 represents the muscles which move the branchiostegal apparatus.—Fig. 5 is a general view of the skeleton of *C. viscosus*.—In Fig. 5^a, the bones of the face and scapular arch are exhibited; in Fig. 5^b, the hyoidean apparatus; in Fig. 5^c, the branchial apparatus; in Fig. 5^d, the ventral fins; and in Fig. 5^e, some of the pieces constituting the trunk.

8'. Supramastoids.	43. Urohyal.
13. Vomer.	44. Branchiostegals.
19. Turbinal.	45. Basibranchials.
20. Palatine.	46. Hypobranchials.
21. Maxillary.	47. Ceratobranchials.
22. Premaxillary.	48. Epibranchials.
23. Entopterygoid.	49. Pharyngobranchial.
24. Pterygoid.	49'. Inferior Pharyngobranchial.
25. Epitympanic.	50. Suprascapular.
26. Mesotympanic.	51. Scapular.
27. Pretympanic.	52. Coracoid.
28. Hypotympanic.	54. Ulna.
29. Articular.	55. Radius.
30. Angular.	56. Carpals.
31. Splenial.	57. Metacarpophalangeals.
32. Dentary.	58. Epicoracoid.
34. Preopercular.	63. Pubic.
35. Opercular.	70. Metatarso-phalangeals.
36. Subopercular.	71. Supraorbital.
37. Interopercular.	72. Supratympanic.
38. Stylohyal.	73. Lachrymal.
39. Epihyal.	73 ^a . }
40. Ceratohyal.	73 ^b . } Supralachrymals.
41. Basihyal.	73'. Suborbitals.
42. Glossohyal.	

The numbers 8', 73^a and 73^b we have added to the series; 72 is called supratemporal by Professor Owen.

<i>n s</i> —neural spines.	<i>n'</i> —neuro-caudal plate.
<i>i n</i> —interneural spines.	<i>h'</i> —hæma-caudal plate.
<i>dn</i> —dermo-neural spines.	<i>dn'</i> —caudo-dermo-neural spines.
<i>h s</i> —hæmal spines.	<i>pl</i> —pleurapophysis.
<i>i h</i> —interhæmal spines.	
<i>dh</i> —dermo-hæmal spines.	

a represents the tenth vertebra, with its pleurapophyses and pelvic appendages below.

β is an anterior thoracic vertebra.

δ is a group of five vertebræ, two pelvic and three caudal.

$\left. \begin{matrix} \varepsilon \\ \gamma \end{matrix} \right\}$ belong likewise to the caudal region.

Fig. 6—9. Skull of *Cottus viscosus*; Fig. 6 from above; Fig. 7 from below; Fig. 8 in profile; and Fig. 9 from behind.

Fig. 10—13. Skull of *Cottus Franklinii*; Fig. 10 from above; Fig. 11 from below; Fig. 12 in profile; and Fig. 13 from behind.

Fig. 14—17. Skull of *Cottus Wilsonii*; Fig. 14 from above; Fig. 15 from below; Fig. 16 in profile; and Fig. 17 from behind.

Fig. 18—21. Skull of *C. Richardsonii*; Fig. 18 from above; Fig. 19 from below; Fig. 20 in profile; and Fig. 21 from behind.

Fig. 22—25. Skull of *Trigloporus Thompsonii*; Fig. 22 from above; Fig. 23 from below; Fig. 24 in profile; and Fig. 25 from behind.

Fig. 26—29. Skull of *Acanthocottus virginianus*; Fig. 26 from above; Fig. 27 from below; Fig. 28 in profile; and Fig. 29 from behind.

Fig. 30—32. Vertebrae of *Acanthocottus virginianus*; Fig. 30, thoracic, with its pair of pleurapophyses or ribs; Fig. 31, pelvic, with its pair of pelvic appendages; Fig. 32, caudal.

Fig. 33—35. Encephalon of *Acanthocottus virginianus*; Fig. 33 from above; Fig. 34 from below; and Fig. 35 in profile.

Fig. 36—38. Encephalon of *Trigloporus Thompsonii*, twice the natural size; Fig. 36 from above; Fig. 37 from below; and Fig. 38 in profile.

Fig. 39—41. Encephalon of *Cottus gracilis*, twice the natural size; Fig. 39 from above; Fig. 40 from below; and Fig. 41 in profile (under the name of *C. gobioides* on the plate).

Fig. 42. An imperfect sketch of the encephalon of *C. gobioides*, twice the natural size, seen from above (under the name of *C. gracilis* on the plate).

Fig. 43—45. Encephalon of *C. viscosus*, twice the natural size; Fig. 43 from above; Fig. 44 from below; and Fig. 45 in profile.

Fig. 46—48. Encephalon of *Acanthocottus variabilis*; Fig. 46 from above; Fig. 47 from below; and Fig. 48 in profile.

ALPHABETIC REGISTER

OF

SYSTEMATIC NAMES ALLUDED TO IN THIS MONOGRAPH.⁽¹⁾

- ACANTHOCOTTUS, Girard, pp. 9, 10, 61, 64.
 ———— ARIES, Grd. 10.
 ———— BUBALIS, Grd. 10.
 ———— CLAVIGER, Grd. 9.
 ———— SCORPIOIDES, Grd. 10, 59, 60.
 ———— SCORPIUS, Grd. 59.
 ———— VENTRALIS, Grd. 9.
 ———— VARIABILIS, Grd. 26, 27, 28, 76.
 ———— VIRGINIANUS, Grd. 20, 21, 25,
 26, 27, 28, 31, 37, 76.
- ASPIDOPHORUS, Lacep. 8.
 BATRACHUS, Klein, 8.
 CALLIONYMUS, L. 8.
 CALLIPTERYX, Agass. 10.
Centridermichthys, Rich. 9, 62.
 ———— *asper*, Rich. 62.
- COTTOIDS, 10.
 COTTOPSIS, Girard, 9, 10, 61, 62, 64, 71.
 ———— ASPER, Grd. 12, 62, 71.
- COTTUS, Artdi, 9, 33, 61, 64, 69.
 ———— AFFINIS, Heck. 5, 7, 11, 59, 60.
 ———— ALVORDII, Grd. 11, 14, 34, 36, 46, 47,
 53, 70.
 ———— *aries*, Agass. 10.
 ———— *asper*, Rich. 9, 37, 62.
 ———— BAIRDII, Grd. 11, 33, 34, 36, 43, 44, 48,
 49, 54, 69.
 ———— BOLEOIDES, Grd. 11, 35, 36, 49, 55, 56, 70.
 ———— BREVIS, Agass. 10.
 ———— *bubalis*, Euphr. 10.
 ———— *cataphractus*, L. 8.
 ———— COGNATUS, Rich. 7, 11, 13, 34, 36, 37, 38,
 40, 41, 59, 63, 69.
- COTTUS, FABRICII, Grd. 11, 35, 36, 59, 71.
 ———— FERRUGINEUS, Heck. 5, 11.
 ———— FORMOSUS, Grd. 11, 36, 58, 71.
 ———— FRANKLINII, Agass. 11, 19, 20, 35, 36, 53,
 60, 70, 76.
 ———— GOBIO, (Art.) L. 5, 6, 7, 8, 9, 10, 11, 13,
 38, 51.
 ———— *gobio*, Pallas, 8, 10.
 ———— *gobio*, Pennant, 6, 41.
 ———— *gobio*, Reising. 6.
 ———— *gobio*, Fabr. 7, 59.
 ———— *gobio*, Ayres, 7, 38, 49.
 ———— *gobio*, Kirtl. 44.
 ———— GOBIOIDES, Grd. 11, 26, 27, 35, 36, 55,
 70, 76.
 ———— GRACILIS, Heck, 11, 13, 26, 27, 33, 34, 35,
 36, 37, 38, 49, 70, 76.
 ———— MERIDIONALIS, Grd. 11, 14, 33, 34, 36, 37,
 46, 47, 53, 68, 70.
 ———— MICROSTOMUS, Heck. 5, 7, 11.
 ———— MINUTUS, Pall. 8, 9, 11.
 ———— PAPYRACEUS, Agass. 10.
 ———— POECILOPUS, Heck. 5, 7, 11.
 ———— RICHARDSONII, Agass. 11, 20, 34, 35, 36,
 39, 46, 55, 59, 69, 76.
 ———— *scorpioides*, Fabr. 10.
 ———— *tricuspis* (Mus. Reg.), 59.
 ———— VISCOSUS, Hald. 11, 13, 14, 19, 20, 21, 22,
 25, 26, 27, 28, 31, 35, 36, 37, 38, 44,
 45, 47, 51, 53, 54, 68, 70, 75, 76.
 ———— WILSONII, Grd. 11, 19, 20, 33, 34, 36, 42,
 45, 69, 76.
- HEMILEPIDOTUS, Cuv. 10, 61.

⁽¹⁾ The names in capitals are those now adopted. The names in italics indicate their synonyms.

HEMITRIPTERUS, Cuv. & Val. 10.
HOLOTHURIA PRIAPUS, 13, 60.
LOTA MACULOSA, 59, 67.
LUMPUS ANGLORUM, 60.
PILUMNUS HARRISII, Gould, 13.
PLATYCEPHALUS, Bloch, 8.
PODABRUS, Rich. 10.
PTERYGOCEPHALUS, Agass. 10.
SCLÆNOIDS, 65.
SCORPAENA, 61.

TRACHIDERMIS, Heck. 9, 10, 62.
——— *Richardsonii*, Heck. 62.
TRIGLA, L. 64.
TRIGLIDÆ, 10.
TRIGLOPSIS, Girard, 9, 10, 12, 64, 71.
——— THOMPSONII, Grd. 13, 21, 23, 25, 26,
28, 31, 64, 71, 75, 76.
Cranidea, Dekay, 9.
——— *quiescens*, Dekay, 37, 38, 49.

CONTENTS.

PREFACE	PAGE
	3

CHAPTER I.

ON THE FRESH WATER COTTOIDS IN GENERAL.

§ 1. Zoological considerations	5
§ 2. Genealogy of the Cottoids	10
§ 3. Geographical distribution	11
§ 4. Habits, food, and use	12

CHAPTER II.

ANATOMICAL OBSERVATIONS.

§ 1. General remarks	14
§ 2. The bony frame of <i>Cottus viscosus</i>	14
§ 3. Comparisons between the skulls of different Cotti	19
§ 4. Comparative osteology of <i>C. viscosus</i> and <i>A. virginianus</i>	20
§ 5. The bony frame of <i>Trigloopsis Thompsonii</i>	21
§ 6. <i>Trigloopsis Thompsonii</i> compared with <i>Cottus viscosus</i> and with <i>Acanthocottus virginianus</i>	25
§ 7. The encephala of <i>Cottus viscosus</i> , <i>C. gracilis</i> , <i>C. gobioides</i> , <i>Trigloopsis Thompsonii</i> , <i>Acanthocottus virginianus</i> , and <i>A. variabilis</i> , compared	26
§ 8. The muscular system of <i>Cottus viscosus</i>	28
§ 9. The skin and the lateral line in Cottoids	30
§ 10. The alimentary canal, urinary bladder and ovaries, in Cottoids	31
§ 11. Respiratory apparatus	32

CHAPTER III.

ON THE GENUS COTTUS, Artedi.

§ 1. Zoological characters	33
Synoptical table of the species	36
§ 2. Chronological summary of the history of American Cotti	37
§ 3. Species with four soft rays to the ventrals	39
I. <i>Cottus Richardsonii</i>	39
II. <i>Cottus cognatus</i>	41
III. <i>Cottus Wilsonii</i>	42
IV. <i>Cottus Bairdii</i>	44
V. <i>Cottus Alvordii</i>	46
VI. <i>Cottus meridionalis</i>	47

	PAGE
§ 4. Species with three soft rays to the ventrals	49
VII. <i>Cottus gracilis</i>	49
VIII. <i>Cottus viscosus</i>	51
IX. <i>Cottus Franklinii</i>	53
X. <i>Cottus gobioides</i>	55
XI. <i>Cottus bolcoides</i>	56
XII. <i>Cottus formosus</i>	58
XIII. <i>Cottus Fabricii</i>	59

CHAPTER IV.

ON THE GENUS COTTOPSIS, Girard.

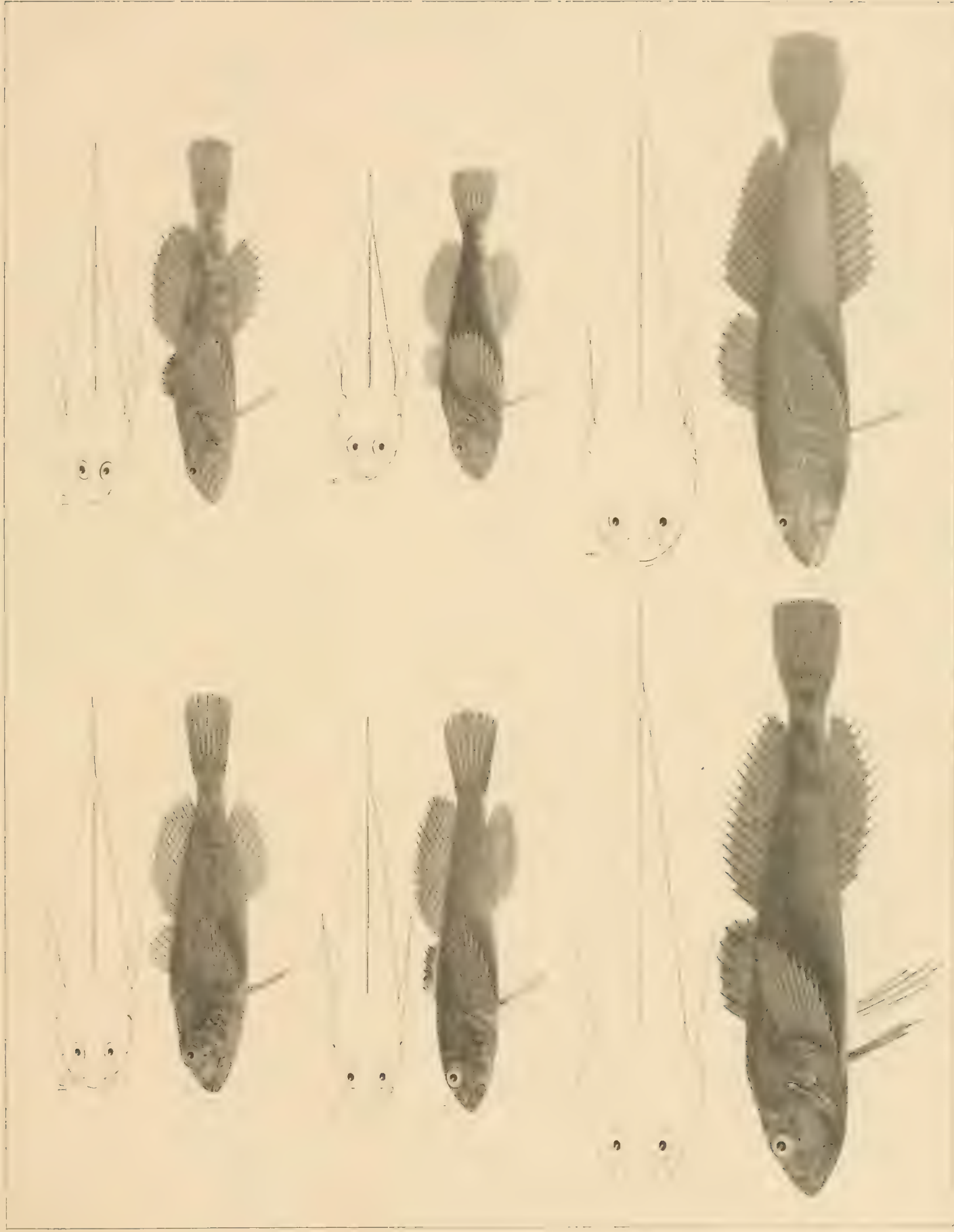
Cottopsis asper 62

CHAPTER V.

ON THE GENUS TRIGLOPSIS, Girard.

Triglopsis Thompsonii	.	.	.	.	.	.	.	.	65
Note	.	.	.	.	.	.	.	.	68
Diagnosis of the genera and species	.	.	.	.	.	.	.	.	69
Bibliography	.	.	.	.	.	.	.	.	72
Explanation of the plates	.	.	.	.	.	.	.	.	75
Alphabetic register of systematic names alluded to in this monograph	.	.	.	.	.	.	.	.	77
Contents	.	.	.	.	.	.	.	.	79

PUBLISHED BY THE SMITHSONIAN INSTITUTION,
WASHINGTON CITY,
DECEMBER, 1851.



A. S. P. 11. 3. *** from nat.

Printed by Lippin & Bradford

Fig. 1 & 2. *COTTUS RICHARDSONII* Agass.—Fig. 3 & 4. *COTTUS WILSONII* Girard.—Fig. 5 & 6. *COTTUS BAIRDII* Girard
 Fig. 7 & 8. *COTTUS ALVORDII* Girard.—Fig. 9 & 10. *COTTUS MERIDIONALIS* Girard.—Fig. 11 & 12. *COTTUS GRACILIS* Heck





Fig. 1 & 2. *COTTUS VISCOSUS* Hald.—Fig. 3 & 4. *COTTUS GOBIOIDES* Girard — Fig. 5 & 6. *COTTUS FRANKLINII* Agass.
Fig. 7 & 8. *COTTUS BOLEOIDES* Girard — Fig. 9-11. *TRIGLOPSIS THOMPSONII* Girard

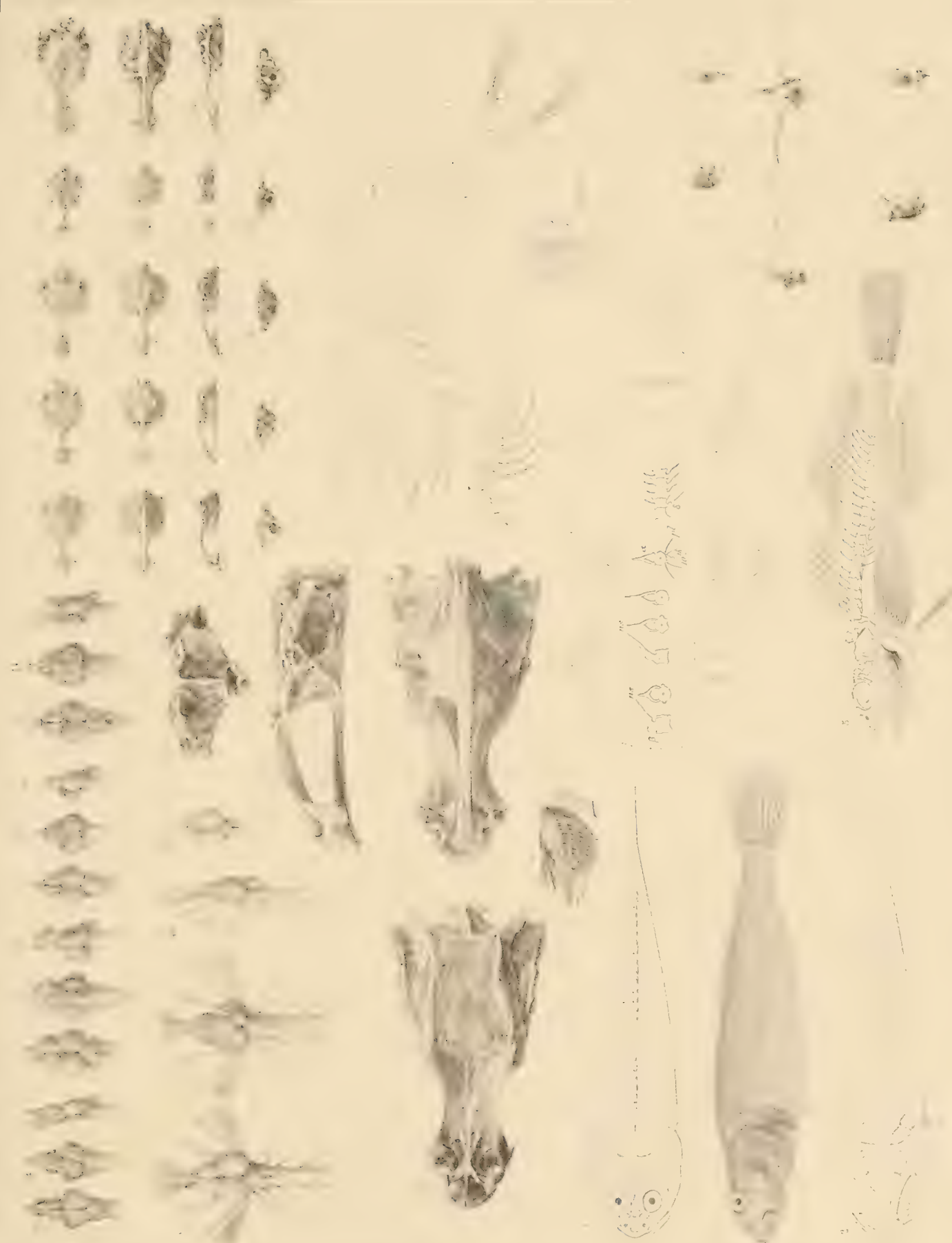
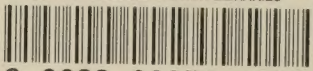


FIG. 46-48. ACANTHOCOTTUS VARIABILIS. — FIG. 39-41. COTTUS COBIOIDES. — FIG. 42. C. GRACILIS. — FIG. 22-25 & 36-38. TRICLOPSIS THOMPSONII

SMITHSONIAN INSTITUTION LIBRARIES



3 9088 00054 8099